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Petroleum Refiner

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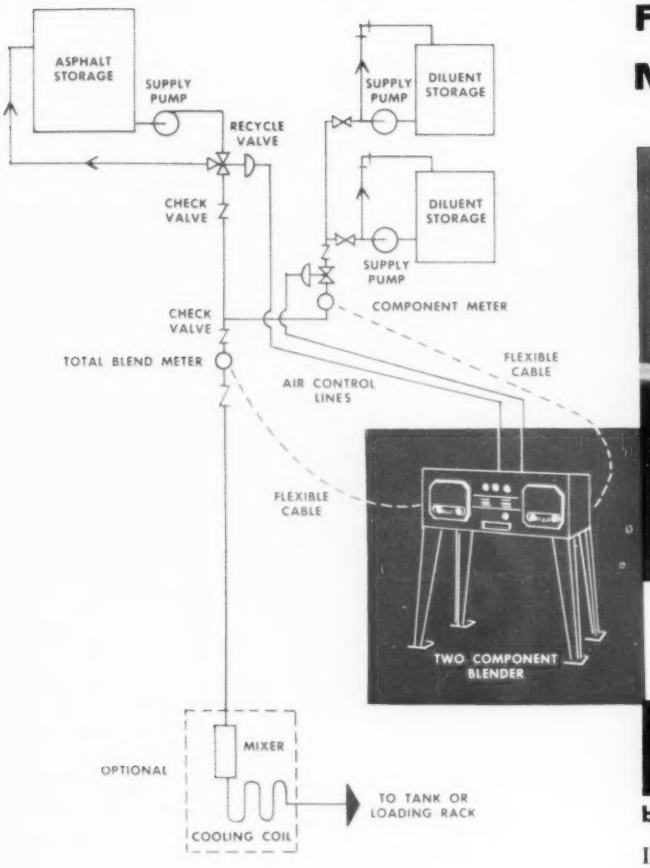

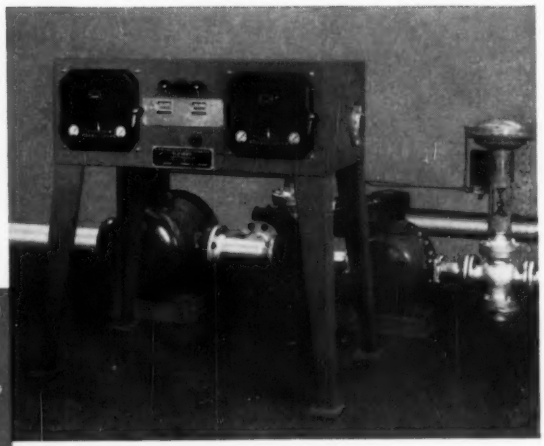

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Volume 39, No. 5 May 1960

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Petroleum
Refiner
OIL, GAS AND PETROCHEMICAL PROCESSING
A Gulf Publishing Company Publication

A Quick Look at This Issue

These handy digests permit checking the articles you want to read first. ☑

SPECIAL API REPORT

☐ **Aluminum Bundles Will Work In Petroleum Service . . .** Early tests showed that aluminum failed rapidly under process stream conditions. This gave the metal a bad name in the industry. Now, however, records reveal that many of these tests were cases of misapplication. Eighteen case histories in 45 plants show aluminum exchanger and condenser tubes are superior to brass, steel, or alloys in certain locations. To see where aluminum bundles will work in your plant, turn to **Page 143.**

☐ **Refiners Report New Cases of Stainless Steel Failures . . .** Stress corrosion cracking and intergranular corrosion are the main causes of stainless steel failures. Methods for preventing these problems have been developed for the proper selection and use of stainless steel. The case histories presented here will give you typical examples of the conditions found in modern refineries and petrochemical plants and their solutions. Turn to **Page 151.**

☐ **Get Cheaper Coking Now With This New Design . . .** Fluid coking has been re-engineered to improve its design and economics. You will want to include these new cost data in your present evaluations, so turn now to **Page 157.**

☐ **How Much You Can Save With the Isocracking Process . . .** Here are material balances for typical refineries converting middle distillate to gasoline. These cases demonstrate the advantages of the Isocracking process for control of product distribution and quality. Add these economic data to your files. Turn to **Page 161.**

☐ **How Pollution Control Builds Good Public Relations . . .** Here's how you can build an aquarium and landscaped fountain using refinery effluent. For details on how Cities Service proved itself a good industrial neighbor with a $3 million waste disposal system, turn to **Page 169.**

Please Turn Page ➔

The sentinel that never gets relief... Day after day after day, for over 4 years this Beckman oxygen analyzer has maintained vigil on catalyst regeneration. Located eight stories above The Texas Company refinery at Wilmington, California, it has monitored unreacted oxygen, under demanding conditions, with only minimum routine maintenance. Analysis must be continuous, dependable, accurate. ⌘ This Beckman instrument is the only oxygen analyzer to use a direct paramagnetic measurement exclusively, which brings you these advantages: *Dependability...* under the most rugged conditions. *Simplicity...* with no auxiliary measurements to complicate analysis, no extra components requiring extra maintenance. *Accuracy...* with sensitivity and specificity to meet the most critical process requirements. ⌘ Whatever your application, if you want detailed specifications on an oxygen analyzer that withstands tough environments and gives you continuous, dependable answers, write for Data File 25-5-08.

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It's a Fact: A Beckman Infrared Analyzer has successfully controlled heat input to a refining tower for three years, maximizing ethylene recovery and minimizing methane content by analysis of the bottoms of a demethanizing absorber.

A Quick Look at This Issue . . .

☐ **Cut Downtime Through Onstream Radiographic Inspection . . .** This technique gives refiners the opportunity for visual inspection of equipment internals while the unit is in operation. You can cut downtime, reduce operational hazards and manpower costs using radioisotopes emitting gamma radiation to inspect your equipment. This visual proof of the internal condition will often encourage operators to extend their runs as well as allow you to better plan the schedule turnarounds. To see how it's done, turn to **Page 172.**

☐ **Short Course on Corrosion Measurement—Part 1 . . .** By accurately measuring the amount of metal loss occurring in process equipment, the corrosion engineer can better predict the amount of damage and the remaining useful life for that equipment. These measurements will also help him determine the merits of other means of corrosion control. To check on the latest ideas in corrosion measurement, turn to **Page 180.**

☐ **Here's Packaged Boiler Cost . . .** Get in on the cost savings of using packaged equipment. For complete data for estimating packaged steam boiler costs, turn to **Page 185.**

☐ **Now Cat Feed Made by Deasphalting . . .** The propane deasphalting process now uses improved techniques to make it more suitable for preparing cat cracking feed from residues. These pilot plant data show the economic incentive for using the deasphalting process. Two types of crudes were used as examples of how the process works, turn to **Page 187.**

☐ **Fluor Solvent CO_2 Removal Process . . .** When CO_2 content is very high and product specifications are relaxed, this process is the least costly of several alternate processes. To get the details on how it works and how to evaluate it, turn to **Page 193.**

☐ **Automation Today, Part 21 . . .** This interesting series has completed the development of a method for examining control systems. Now the analyst is prepared to make a complete design of a control system to meet certain specifications. Test your understanding of this important method by following the example problems given here. Turn to **Page 197.**

☐ **How Cap Spacing Sets Tower Design . . .** Here is a new method for determining the maximum vapor capacity of bubble cap towers. Unlike some other design methods, this one takes into account the influence of cap size and spacing. These features are combined with others to give two mathematical expressions for easy design. You'll be able to test the loading on existing towers or specify the size of new ones with the method starting on **Page 201.**

☐ **Applied Hydrocarbon Thermodynamics . . . Part 17, K and α Values for Integral Method . . .** This article provides ways to determine the K and α for your own case plus several nomographs for relative volatilities. Also Professor Edmister describes a method for finding K values from observed TBP curves of the equilibrium vapor and liquid from experimental flash vaporization of a petroleum fraction. You're going to want to file this article with the other parts, so turn now to **Page 207.**

☐ **Use These Ks in Hydrofining . . .** If you've been using the regular NGAA Ks for system calculations where excess hydrogen is present, you've been making some mighty big errors. Here for the first time you'll find some Ks which are to be used in hydrofining calculations or any process where hydrogen concentration is high. You'll like the 17 figures on these important Ks, starting on **Page 213.**

☐ **Selecting Material for Heat Exchangers . . .** It is the exception today when lowest cost material for your heat exchanger proves to be the most economical choice. Here are simple rules, charts and tables for rapid determination of the cost effect of alloys generally used in exchangers. For help in finding the most economical material for your next exchanger design, turn to **Page 223.**

☐ **How to Make and Use C_4 Olefins, Part 1 . . .** This article presents the chemistry, production and utilization of the *n*-butenes. Although used primarily for butadiene, there is also a discussion of other important uses. Turn to **Page 229.**

☐ **Estimate Ethylene-Methane Separation . . .** For a quick estimate of the split between ethylene and methane, use these handy charts. They will work for separations made by either absorption or fractionation. Now you can reduce the number of detailed computations required to find an optimum separation scheme. **Page 233.**

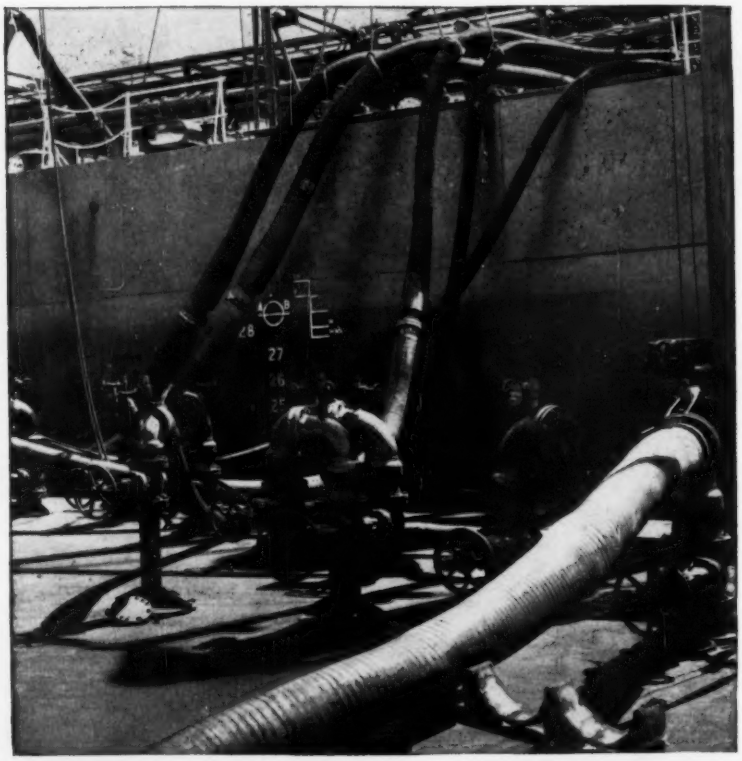
☐ **Four Solutions to a Gas Turbine Heat Recovery Problem . . .** Money spent studying various heat recovery systems can give you real savings in gas turbine applications for process plants. Here is a typical case history and four solutions to the application problem. To see which you should pick, turn to **Page 237.**

☐ **Operator's Handbook for Gasoline Plants . . .** This part on positive displacement meters is sure to add accuracy to present flow measurements. Methods for proving your meters are explained and illustrated, so be sure to turn to **Page 241.**

☐ **Group Dynamics in Decision Making . . . Applied Group Dynamics: Part 1 . . .** How does management make vital decisions and place them into operation? Usually it's by following the traditional approach—through edicts under an authority-obedience power system. But there is a much better way as you will learn from this highly interesting and informative new series starting in this issue. You're going to want to clip and save each part of this different approach to management development. Turn now to **Page 253.**

☐ **You Can Create 'Professional Spirit' . . .** Management will do well to remember that engineering is a profession—and to get the most of an engineer's technical ability, he must be treated as a professional. There's also some interesting data on starting salaries, so be sure you turn to **Page 256.**

For refinery safety depend on Quaker Thermoid . . .



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Using a Memo

THE ENGINEER (who actually isn't one) of this column wrote out a memo to himself some weeks back and because it says what we'd like to say, it is here reproduced:

"For Page 7—Boost Gasoline Plant Operator's Handbook.

"Accepted widely with open arms, etc.

"Refer to upcoming book."

Actually, there's little else to add except that this series commenced exactly a year ago in PETROLEUM REFINER, and we've had a lot of requests for reprints. But a more desirable path has been decided upon in that it is planned to put all of this material, after the series has been completed, in book form. We'll be advising you. In the meantime keep reading them on a monthly basis. No. 9, for instance, appears on Page 241 of this issue.

Kept from Staff

THE OTHER DAY a subscriber with a Levittown, N. Y. address wrote in: "Just keep up your excellent magazine to its present standards—the articles are well diversified and I find them all quite useful for my work."

An appreciated remark, but it wasn't shown to the staff and here's why: That last sentence would have been OK for them to read, but it wouldn't be so good to tell them to "just keep up the magazine to its *present* standards." That, of course, is a high level, but around these diggin's the constant aim is to *improve* the standard from month to month. And we are always receptive to reader ideas that will assist in this continuing effort.

What's A Ch. E.?

DICK OKENFUSS, graduate assistant, Department of Chemical Engineering, University of Missouri School of Mines and Metallurgy, Rolla, offers "this short article, half prose, half nonsense" which, he thinks might give some of PR's readers a smile as it did "everyone in the department here":

A Chemical Engineer is a man who knows
enough engineering to confuse a chemist,
enough chemistry to confuse a draftsman,
enough mathematics to confuse his boss,
and enough electricity to confuse himself.

His world consists of a series of simplifying assumptions and derived basic equations,
all of which he is sure are true
because they can be integrated twice.

The Chemical Engineer is a well trained
pipefitter,
machinist,
metal worker,
test tube washer,
and coffee drinker.

And if he never has to solve a problem different than the examples in Walker, Lewis, McAdams, and Gilliland, he'll go on collecting his paycheck so long as he can crawl over to the payroll office.

WHAT'S 1 OUT OF 1000 TO YOU?

In cat cracking, minute percentages in the collection efficiency of catalyst recovery systems can make the difference between an economical and a completely undesirable operation. One tenth of 1% loss in efficiency in a large cat cracker can result in an increased carryover of more than 70 tons of catalyst per day. At $250 a ton, this can amount to over $17,000 . . . a lot of reason to specify the most efficient system . . . Buell Cyclones. Only Buell Cyclones have the exclusive Shave-Off that guarantees the extra efficiency necessary for continuous high-recovery results. And only Buell has the accumulated know-how derived from more than 25 years of experience in hundreds of refinery installations. Buell Engineering Co., 123 William St., New York 38, N. Y. Northern Blower Division, 6409 Barberton Ave., Cleveland, Ohio. (Subsidiary: Ambuco Limited, London, England).

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Quick Look at Industry...

More New Processes on the Scene . . .

UOP has new hydrocracking process to compete with similar processes announced recently by Union Oil and California Research. Named Lomax, UOP's entry helps convert middle distillates to gasoline. Results: more product flexibility and better quality.

And still another new process—this one for removing carbon dioxide. Called Fluor Solvent CO_2 Removal process, it is attractive when CO_2 content is high or when product specifications are relaxed. In certain cases treating costs run low as 2¢/MSCF feed on $2.4 million investment (more on page 193).

Methyl Lead Goes Commercial . . .

Tetramethyl lead now used in gasoline marketed by California Standard. Announcement follows claim by several companies to be working with TML. The big advantage: TML does best job of upgrading octanes in gasolines having high aromatic content.

Enrollments Slide as Degrees Rise . . .

Engineering enrollment in '59 was 240,063—down slightly from 249,950 in '58 and 257,777 in '57. Degrees increased slightly though. Last year 714 Ph.D.'s were given as compared with 647 in '58—Master degrees totaled 6,723 as compared with 5,751 a year earlier.

New Rubber Bounces into Spotlight . . .

New nonflammable synthetic rubber completely resists gasoline and stays soft and resilient at 60 degrees below zero—is member of the "nitroso-fluorocarbon" family. Not yet ready for use in finished products, but anticipate it will be ideal for gaskets, hoses, coatings, etc., which must function at low temperatures in presence of solvents or corrosive chemicals.

No Gasoline Plants Unattended . . .

Recent NGAA survey of 34 companies shows no unattended gasoline plants, although some approach this status. On the other hand, most compressor stations under 20 MMcfd are unattended. Survey also shows four chromatographs being used in automatic control. (More on page 306).

Quick Look at Desiccant Units . . .

Pan American reports maximum labor of two hours a day for operating and maintaining desiccant dehydration-hydrocarbon recovery units. Units costing more than $170,000 can be installed for 18% of equipment costs. Desiccant should be replaced every 18 months.

Quick Look at World-Wide Construction . . .

World's largest crude running unit (150,000 bpd) slated for Amoco's Texas City plant—also 47,600-bpd cat cracker and 14,600-bpd alky unit . . . World's largest sulfur plant now on stream for Soc. Nationale des Petroles d'Aquitaine, Lacq, France . . . Tidewater will build 20,000-bpd refinery at Danish seaport, Kalunborg . . . Tennessee Gas awards contract to O. L. Olsen Co. to build 55 MMcfd natural gas processing plant near Palacios, Texas. (More in "Who's Building," page 273).

Detergents Holding Steady . . .

Detergent market apparently saturated as detergent use—4 billion lbs. annually—rises in proportion to population. Holding steady to about 25-28

lbs. a year per person, synthetics now capture about 80% of the market. Petrochemical alkylates and sulfonates represent about 33% of the active agents in these syndets.

Panning the Octane Picture . . .

Premium on sale at service stations averaged 99.4 F-1 octane in April for slight drop of 0.1 from March. Regular averaged 92.4 to hold steady to the March figure. Looking back over a year, premium rose 0.3 octane over April '59 while regular recorded 0.7 increase for the 12-month period.

NLRB Upholds Indiana Standard . . .

National Labor Relations Board upheld as entirely proper the layoff by Indiana Standard of 17 boilermakers who lost seniority by splitting off into craft union—ruling climaxed 3½ years of litigation. Two rival unions threatened to strike over the layoff—one if men were laid off, and other if they were not. In decision, NLRB pointed out it is "basic that seniority rights are not inherent in an employer-employe relationship."

Atlantic Optimistic Over Wax . . .

Despite pessimism of some refiners, Atlantic thinks wax consumption will continue to show net increase in both present and new uses. Last year, company spent $18 million to modernize and hike wax production—to them it is a primary rather than a by-product. In the future, look for more exact separation of paraffin waxes and new additives.

More Cars Due on the Roads . . .

Ethyl Corp. researcher says by 1965 Americans will be driving almost 15 million more cars than now—would put U.S. car population at 71.4 million. At the same time, gasoline consumption will rise from today's 57 billion gallons a year to 67.1 billion gallons.

Also says no competitive power plant likely to replace gasoline engine in passenger cars. Major drawbacks of gas turbines are high costs, relatively poor fuel economy, and slow acceleration. Free-piston engine is heavy, noisy, relatively expensive and hard to start in cold weather—also cannot match fuel economy of gasoline engine. Battery-powered cars are low-powered and have limited range. Diesel engines are larger, heavier and more expensive than equivalent gasoline engines.

But Farmers Like Diesels for Tractors . . .

One area in which diesels are making big headway is on the farm. Current strong preference by farmers toward diesel-powered farm equipment can be traced to actual cash savings in fuel costs. While diesels cost more initially, farmers can pay-out added costs by operating 800 hours a year. Trend could alter manufacturing & marketing pattern in predominantly agricultural areas.

How Long to Develop Crude? . . .

That's a question coming in for serious study. Concepts of hydrocarbon genesis are changing, and it's possible it may not take as long for crude to develop and accumulate as previously thought. One result: more oil companies looking for "young" oil.

Common Site Picketing Draws Fire . . .

NSPE protests to Congressional leaders that pending amendments to Landrum-Griffin Labor law relating to picketing could jeopardize the rights of engineering and surveying employes in construction industry. Contends it would be possible to "shut down an entire project in an effort to organize these employes." Society has reference to amendments which would legalize picketing on an entire construction project even though a union dispute was with just a single contractor or subcontractor.

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B&W offers you . . .

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These are just a few of the many reasons why it pays to specify B&W Job-Matched Stainless Tubing. And remember—matching tubes to jobs assures you the *right tube,* in the *right quantity,* at the *right time.* For more information, call your local B&W District Sales Office, or write for Bulletin TB-365. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

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UNITED

UNITED REFINING COMPANY SELECTS KELLOGG CASCADE-TYPE SULFURIC ACID ALKYLATION UNIT AS BEST OF ALL DESIGNS

Low-Investment 1100 BPD Unit Will Increase Octane and Reduce Sensitivity at Minimum Operating Cost

United Refining Company, Pennsylvania's largest independent oil refiner, has an eye for economy.

Faced with a need for producing high quality motor alkylate from a high propylene-content feed, United selected an 1100 BPD Kellogg alkylation unit. A sulfuric acid design, utilizing Kellogg's multi-stage reactor, the unit is a recent development of previous Kellogg units of this type. It will be erected at United's 15,000 BPD refinery at Warren, Pa.

In awarding Kellogg a lump-sum contract for the design, procurement, and construction of this alkylation unit, United chose a route that many refiners, both large and small, would find to be the shortest and most economical way to meet market demands.

Initial Investment is Lower

Kellogg sulfuric acid alkylation units are designed to minimize the use of costly materials and fabricating procedures. Yet they assure long life by reducing corrosion problems to a minimum without heavy use of expensive chemicals.

Operating Costs are Lower

Kellogg's new design offers a very low sulfuric acid consumption per gallon of alkylate produced. Because the Kellogg design is flexible in its use of available utilities, the total operating *cost* may be minimized to suit local conditions.

Operation is Flexible

Kellogg units can operate on butylene, propylene, or a combination feed. In addition to producing high octane alkylate, they can produce an LPG product without supplementary towers or equipment.

Whether 500 or 15,000 BPD, a Kellogg-designed alkylation unit is a better investment today than ever before. Kellogg welcomes the opportunity to discuss the details of its process as they apply to your specific needs.

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M KELLOGG W

Why Stomp Out Small Cars?

IMAGINE YOURSELF driving peacefully down the street in your big, handsome, multi-powered, multi-cylinder automobile. You intend to make a turn into a sidestreet, so you slip a quick glance into the rear view mirror, peek out both side windows, and make your swing. Then it happens! Another one of those blasted little cars. Just darted under your multi-colored, multi-plied tires as though you weren't even there.

Or maybe you are on the other side. You have your beautiful, uni-cylinder, uni-frame economy car tuned to the tiptop of performance. You are ready to go buzzing through traffic, but you don't dare. Why? Because you can't see over (or under) those big four-wheeled barges cruising along beside you. You wonder how anyone can be hard-headed enough to waste money on those mechanized gas hogs.

In either case, you are a big question to the petroleum industry. Mr. Refiner is wondering whether Mr. Cardriver's desire for economy will overcome his taste for luxury. The results could make a difference in the amount of gasoline the refiner would expect to sell.

But how big is the difference?

This is the question posed by many in the last few months. To help answer it, a representative of General Motors Corp., Max M. Roensch, pulled together data which he used to predict only a two percent drop in an otherwise healthy growth in gasoline consumption. His findings were presented recently before a meeting of the Western Petroleum Refiner Association in San Antonio. Here's what Mr. Roensch revealed:

The popularity of the compact car is growing. Also taking a slice of the auto market are the foreign passenger cars. The sales of these two types of cars are shown in Table 1. Compact cars are classified here as cars with less than 110-inch wheelbase.

The public's interest in economy which fostered the compact cars also has increased the demand for the lower cost, gas-saving, three-speed transmissions. Automatic transmissions reached a peak of popularity at the beginning of 1958 when they were installed in about 4 out of 5 cars. However, their decrease in demand since then is not expected to become appreciable.

TABLE 1—Compact Cars Gain on Market

	Percent of Total U.S. Sales	
	Foreign	U.S. Compacts
1955	0.7	>0.1
1956	1.7	1.3
1957	3.0	1.6
1958	8.0	5.0
1959	10.0	12.0

It seems safe to predict that as our economy grows a greater percentage of buyers of regular cars will purchase this luxury option. It is also likely the foreign and compact car buyer's preference will be for manual transmissions because of lower first cost and better fuel economy. Thus transmissions should not make a substantial change in the amount of gas pumped in the decade ahead.

To compare fuel economy, experience based on General Motors' proving ground can be used. These data concern a 25,000-mile fuel consumption test for many cars, each using a load of vehicle curb weight plus 600 pounds. Considering full-size cars with six-cylinder engines and manual transmissions as a 100-percent base, the United States compact cars with six-cylinder engines and manual transmissions use about 74 percent as much fuel. Foreign cars with four-cylinder engines and manual transmissions use about 51 percent as much fuel. Thus the American compacts can be expected to average about 25 percent better economy than the bigger cars, and the foreign compacts can give about 50 percent better economy.

Car population can now be coupled with fuel economy to give a reliable prediction of gasoline demand. The growing number of foreign and compact cars is expected to constitute 25 percent of total car sales in 1960. This is equivalent to about 10 percent of the total car population. This 10 percent will burn one third less fuel. The lower fuel consumption of smaller cars will result in approximately a two percent reduction in the potential amount of gasoline that would have been burned had all cars been full size.

Between 1950 and the end of 1959 gasoline consumption by passenger cars rose from 35 billion gallons to 54 billion gallons, a 54-percent gain. Even a conservative estimate of a similar 54 percent increase in fuel consumption in the next ten years amounts to 83 billion gallons by 1970. Then assum-

INTEGRAL FIN U-TUBES
for HEAT EXCHANGERS and REBOILERS

Now get steel integral fin or plain U-tubes on pallets from one source! Michigan Seamless has TAILORED TUBING, tailored to *your* specifications and ready for your heat exchanger. Buy TAILORED TUBING for minimum handling, minimum shipping cost, no scrap loss—deliveries on time! A variety of lengths, wall thicknesses and alloys, radii up to 24". Contact your Michigan Seamless representative. In the Southwest, call Gulf States Tube Corporation.

MECHANICAL, AIRCRAFT, PLAIN AND FINNED HEAT-EXCHANGER TUBING

MICHIGAN SEAMLESS TUBE COMPANY
SOUTH LYON, MICHIGAN

A SUBSIDIARY:

GULF STATES TUBE CORPORATION
ROSENBERG, TEXAS

ing the compact car sales continue to be 25 percent of the total sales for each of the years between 1960 and 1970, domestic consumption would be cut by 7 billion gallons. An adjusted demand would then be 76 billion gallons of gasoline for passenger cars in 1970.

Even so, there are economic and social factors which will counteract the compact car's influence on the amount of gasoline burned by U. S. cars:

- Growing traffic congestion will force more driving to be done under stop and go conditions causing poorer fuel economy.
- More leisure time, increased incomes, and more highways will encourage more travel.

Thus, it appears that any reduction in total fuel consumption caused by the better economy of compacts will be counterbalanced by the greater overall use of automobiles in the next ten years.

Little Things Mean a Lot

THERE IS A SONG entitled "Little Things Mean a Lot" which some time ago was quite popular in this country. This song title brings to mind a somewhat similar phrase which should be taken to heart by many equipment buyers—and that is, "little things cost a lot." Specifically, we have in mind those frequent minor design or construction changes in standard items of capital equipment.

Stop and consider for a moment what machinery goes into motion to provide those "minor" modifications. First the required estimates and instructions must be prepared by the supplier's sales department, then the engineering drawings must be changed for the guidance of the production department. Next there has to be special individual purchases at higher cost than normal quantity buying, and finally there is the departure from normal manufacturing operations in the shops. All of these specialities conspire to raise the cost of an otherwise minor change—and by this time it is too late to start considering if maybe this small change hasn't gotten all out of proportion for its benefit to the ultimate buyer.

Manufacturers of all types of supplies and equipment are becoming more and more attuned to these economic facts of life, and as a consequence are urging their salesmen to be a little more persuasive with their customers. Of course this is not to recommend that all vendors should take a "this is the way we make 'em, this is the way you take 'em" attitude. However, it is the responsibility of every professional salesman to discuss these matters with you if you are contemplating one of these "minor" changes.

You should also consider that these modifications increase delivery time as well as cost. In the first place, your standard products are delayed because people are taking time to expedite your special order. And on top of that, regardless of the time and money spent in expediting, rapid delivery cannot be assured.

Let's face it—specials are uneconomical for everybody—for the customer, for the distributor, and for the manufacturer. Thus in view of these facts, it's just plain good business to stop and think twice before ordering some modification or "minor" change to a standard item of equipment. Remember—"little things cost a lot."

Reappraisal Called For

GARDINER SYMONDS, board chairman and president of Tennessee Gas Transmission Company, recently told a group of oil writers in Houston of his company's experiences as it sought expansion of exploration and production outside North America. Included in his remarks were some to the effect that even though dealings were with a "foreign" country, they had been on a highly satisfactory basis.

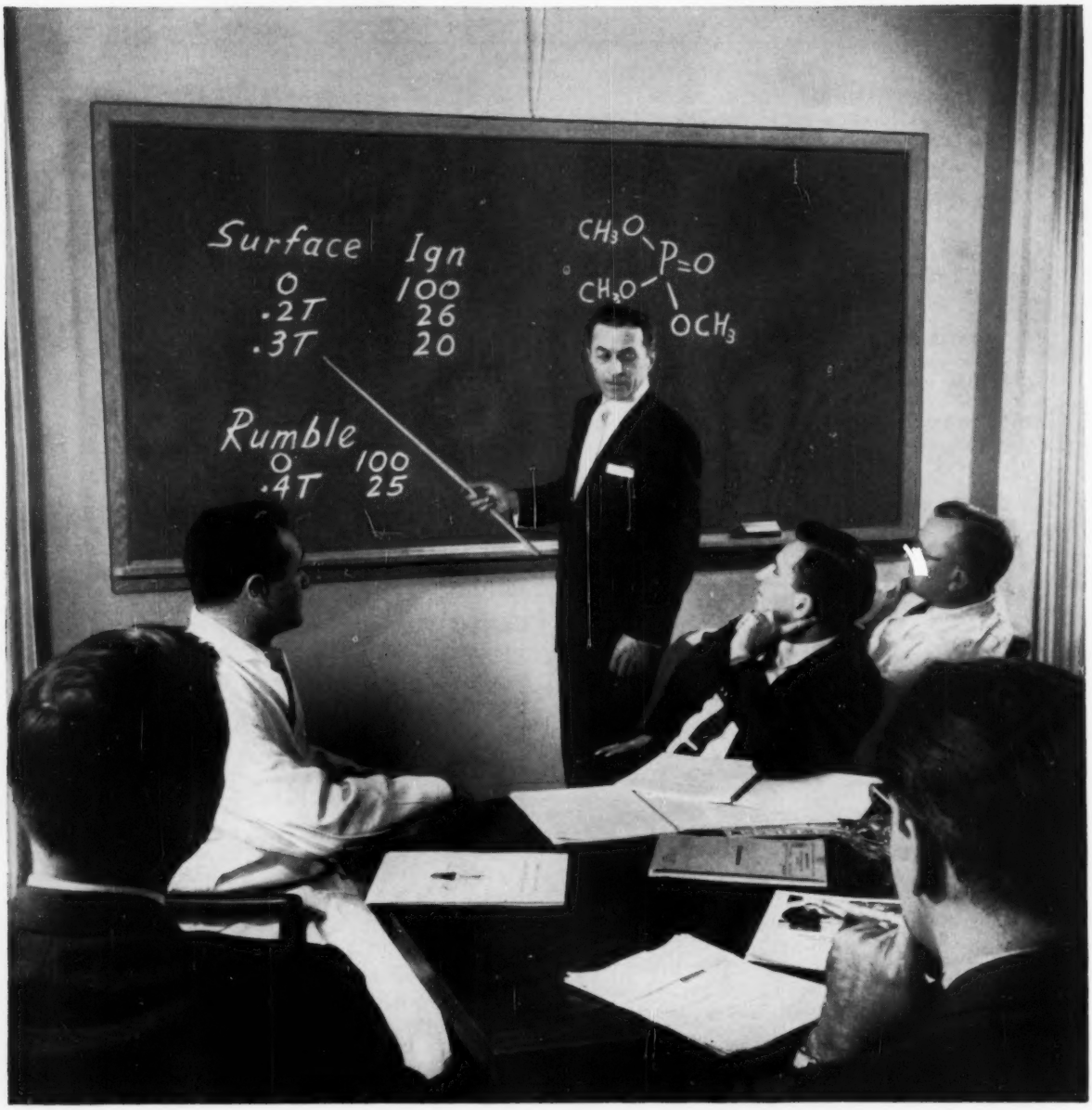
Speaking of South America he said his company is getting in those countries where it now operates treatment that "is no worse in some respects and more stable than we can get in Washington in the gas business."

"I can keep my trades, get faster decisions (in South America) than on the Potomac," he declared. "I think any firm that doesn't swing its weight around can get along down there."

This constitutes another bit of news that should, but probably won't, cause our own government to hang its head in shame. (The other development in this general category is the reprimand which a Federal District Judge gave the Department of Justice in the now famous Tulsa decision of last February when the manner in which some of our laws are being administered came in for a real blistering.)

Patently, it is a sad state of affairs when business people are forced by facts to picture such comparisons.

Our commentary on the situation can well be stated by paraphrasing Texaco's statement in re the Tulsa decision: "This reputation for mishandling or manhandling deals with American business firms suggests that the time has come for an objective reappraisal, at the highest government levels, of the manner in which this vital area of business relations is being handled."



THE NEWEST AND MOST ECONOMICAL PHOSPHORUS ADDITIVE!

"Ethyl" Ignition Control Compound 4 provides more phosphorus per pound at a lower cost

A NEW ECONOMICAL PROCESS for manufacturing ICC 4 (trimethyl phosphate) now provides refiners with the lowest cost phosphorus protection. Thoroughly tested in both laboratory and field, it proved its effectiveness as a gasoline additive and had no undesirable side effects.

A new plant for manufacturing ICC 4 has been completed at Baton Rouge, La., and commercial quantities are immediately available. This phosphorus compound is an exclusive Ethyl product and its use as a gasoline additive in the United States is covered by patents.

For more data on advertised products, use Readers' Service Cards, last page.

Effectiveness of "Ethyl" ICC 4

Ethyl Research tested the effectiveness of ICC 4, in gasolines containing 3.0 ml. of tetraethyllead per gallon, as a suppressant of surface ignition and rumble, and as an extender of spark plug life. In every case, ICC 4 proved to be equally effective with other phosphorus compounds on the market, and showed a marked improvement in cost effectiveness.

Surface ignition tests were made in single-cylinder engines.

Phosphorus	Relative surface ignition counts, %
None	100
0.2 theory ICC 4	26
0.3 theory ICC 4	20

Rumble frequency was tested in a V-8 engine with a 12 to 1 compression ratio.

Phosphorus	Rumble, % of observations	Mileage Accumulations
None	100	8,000
0.4 theory of ICC 4	25	9,500

Spark plug life was tested in V-8 engines operated on a dynamometer.

Phosphorus	Relative life to fouling, %	
	Engine A	Engine B
None	100 (27 hours)	100 (32 hours)
0.2 theory of ICC 4	330 (89 hours)	355 (114 hours)

No Deleterious Side Effects

Exhaustive tests in current fuels show that ICC 4 has no undesirable effects on gasolines or engines:

1. Low antiknock destruction.
2. No effect on intake system deposits.
3. Satisfactory exhaust valve durability.
4. No effect on pistons, rings, or bearings.
5. No effect on storage stability of leaded gasolines.
6. And ICC 4 is compatible with other gasoline additives.

Solubility a Minor Factor

Because ICC 4 is water soluble, some phosphorus is extracted from gasoline into water contained in storage and pipeline systems, of course. However, losses are small and economies are only slightly affected.

Extractability studies indicate that initial losses will be small in routine blending or storage operations. Moreover, the concentration in water bottoms will slowly reach equilibrium with the concentration in gasoline: thereafter losses will be negligible. Losses are greatest when ICC 4 is first introduced.

Economics of "Ethyl" ICC 4

Ethyl has studied typical refining situations to establish the savings that can be made using ICC 4 as a substitute for phosphorus compounds that are less water soluble. Evaluations carefully allowed for losses in blending, storage and service station tanks.

First year savings range from 10 to 15% of total phosphorus additive cost. Greater savings are made when water bottoms achieve equilibrium or are eliminated.

How Ethyl Research can help you

Like all "Ethyl" products, ICC 4 is backed by a full complement of technical and research services. If you wish, your Ethyl Representative will arrange for technical specialists to assist you in determining its most economic use in your refining situation. He also will be glad to supply you with detailed technical literature.

Samples are available now for test purposes from your Ethyl Representative, or by writing to Ethyl Corporation Research Laboratories, Technical Service Department, 1600 West Eight Mile Road, Ferndale 20, Michigan.

ETHYL ADDITIVES — ETHYL CORPORATION

ETHYL CORPORATION
New York 17, N. Y.

Ethyl Corporation of Canada Limited, Toronto
Ethyl USA (Export) New York 17, N. Y.

RESEARCH LABORATORIES—Ferndale 20, Detroit, Mich. • Baton Rouge, La. • San Bernardino, Cal.

For more data on advertised products, use Readers' Service Cards, last page.

How lasting quality is Heat Exchanger

5 ENGINEERING RESEARCH

(FIFTH OF A FIVE-PART SERIES)

Engineering research at new Phelps Dodge mill in South Brunswick, N. J., includes many types of laboratory tests aimed at improving quality control, providing longer tube life.

For more data on advertised products, use Readers' Service Cards, last page.

built into Phelps Dodge and Condenser Tubes...

Recent technical advances pioneered in Phelps Dodge laboratories include tube to tube sheet welding.

More than 40 years of continuing engineering research and manufacturing experience lie behind the lasting quality and long service life of Phelps Dodge heat exchanger and condenser tubes. This vast background has constantly made new contributions to the industry. Phelps Dodge pioneered the manufacture of long length tubes, Dual-gauge tubes and bell-end tubes, keeping pace with the changing designs of heat transfer equipment. Phelps Dodge also has an established reputation as a specialist in the manufacture of duplex tubes, fluted tubes and U-bend tubes.

The Phelps Dodge research staff of chemists, engineers and metallurgists combine their skills on all kinds of tube problems. By analyzing and evaluating the key factors—water pollution, acidity, corrosion, temperature variation effects and other conditions that vitally affect tube performance—they suggest the alloy best suited for particular operating conditions.

This valuable "know-how" goes beyond laboratory analysis and alloy specifications. It is applied to increasing tube service life through ever closer control of quality and to improvement of fabricating and testing equipment. Special non-destructive tests, including eddy current, dye penetrant and ultrasonic inspections, are examples of the latest testing developments used by Phelps Dodge.

Throughout the entire tube fabricating operation—from raw materials to finished product—quality is the keynote. That's why Phelps Dodge tubes are preferred by those who demand the finest . . . the manufacturers and users of heat exchangers and condensers.

PHELPS DODGE COPPER PRODUCTS CORPORATION

First for Lasting Quality—from Mine to Market!

SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Dayton, Denver, Detroit, Fort Wayne, Greensboro, N. C., Houston, Indianapolis, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

For more data on advertised products, use Readers' Service Cards, last page.

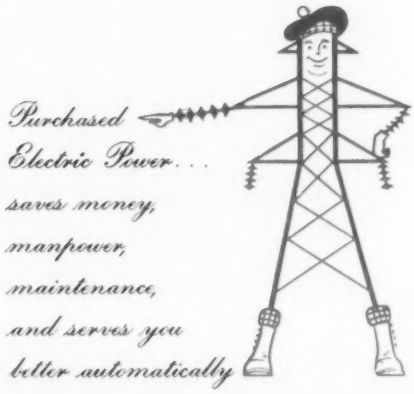
You can depend on purchased electric power for

MONEY SAVING

This mainline crude oil station was converted to purchased electric power.

Typical of money saving installations is this new crude station using utility electric power

This modern station using three 500 hp and two 150 hp motors and 22 electrically operated valves is evidence of the trend to purchased electric power for ultimate economy. Whether your operation is pipeline, refinery or production it will pay you to investigate the possible savings of utility electric power. Call your nearest utility electric power company today.



Petroleum Electric Power Association

P. O. BOX 35006, DALLAS 35, TEXAS

* Practically Perfect!

HUMBLE COREXIT

Save time and money previously lost to internal corrosion: use Humble COREXIT . . . COREXIT effectively and economically prevents internal corrosion in pipe still overhead, distillation towers, vapor recovery systems and other refining units. COREXIT will reduce or completely eliminate plugging or fouling. This protection against sludge, scale and corrosion cuts non-productive downtime to a minimum. For complete information on technical services and products, contact your Humble salesman.

HUMBLE

HUMBLE OIL & REFINING COMPANY

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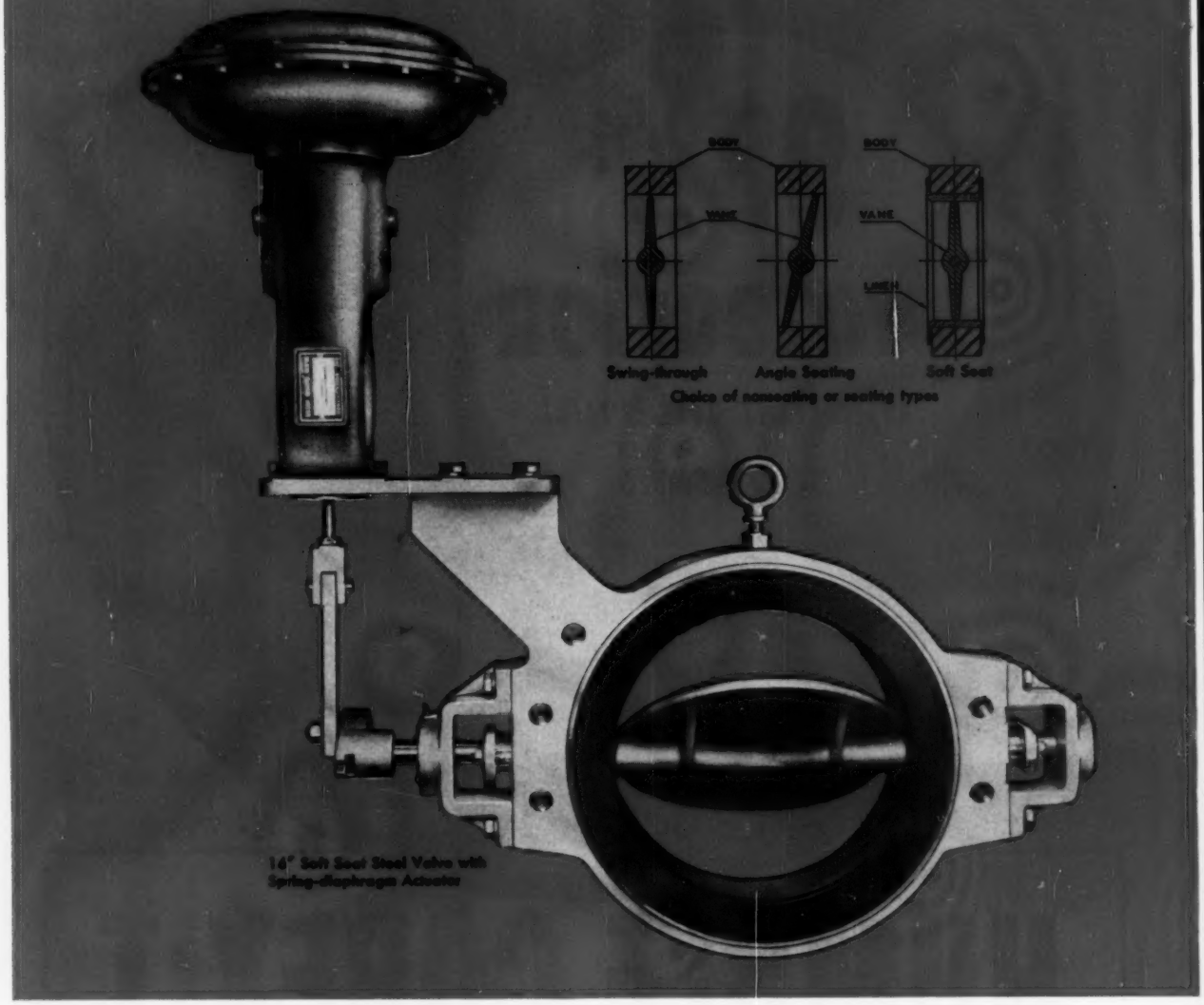
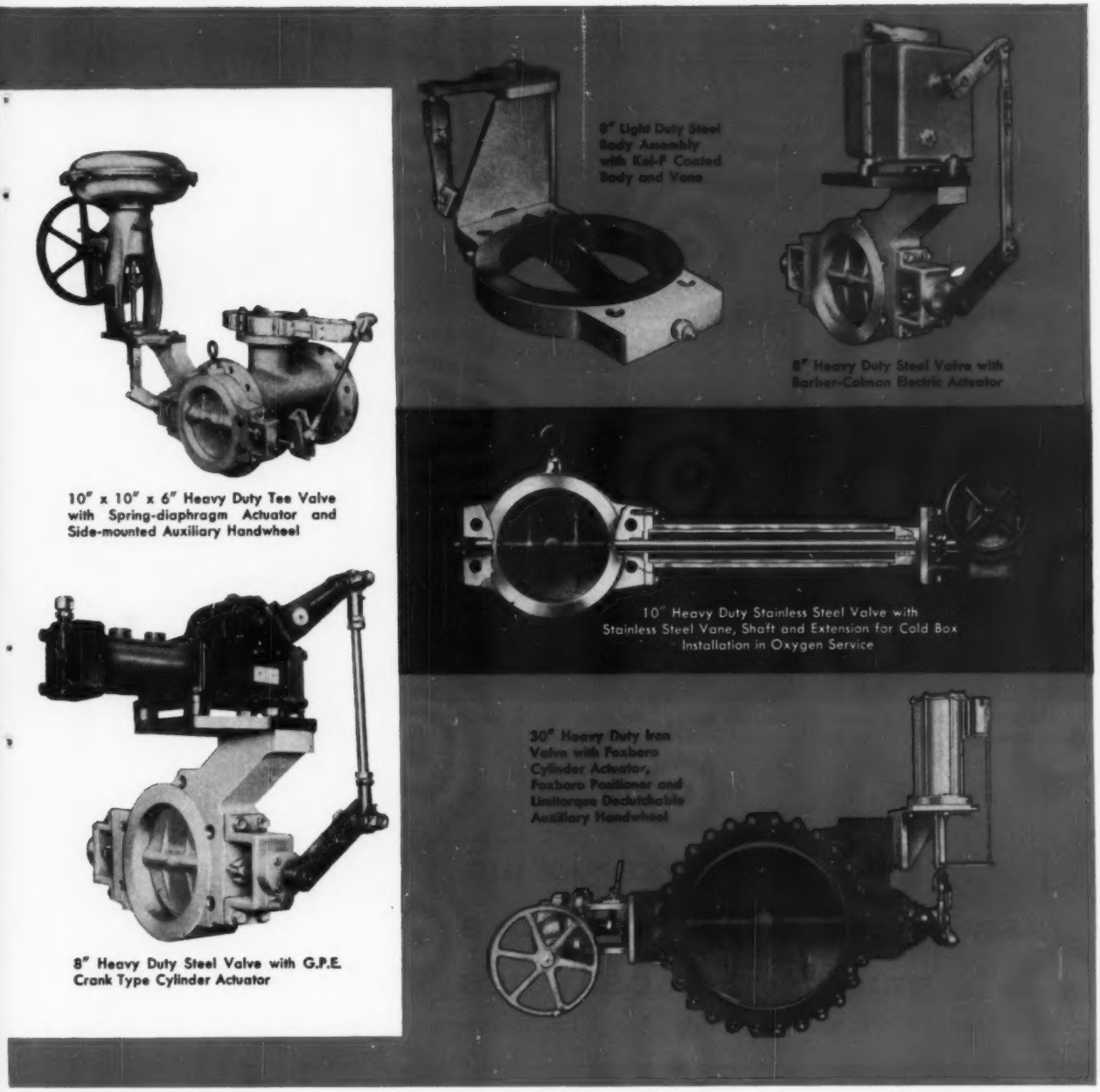
from Mason-Neilan...



Flexibility in Butterfly Valve Application

With Wide Selection of Actuators, Choice of Swing-through or Seating Types


8" Light Duty Steel Body Assembly with Kel-F Coated Body and Vane
8" Heavy Duty Steel Valve with Barber-Colman Electric Actuator
10" x 10" x 6" Heavy Duty Tee Valve with Spring-diaphragm Actuator and Side-mounted Auxiliary Handwheel
10" Heavy Duty Stainless Steel Valve with Stainless Steel Vane, Shaft and Extension for Cold Box Installation in Oxygen Service
30" Heavy Duty Iron Valve with Foxboro Cylinder Actuator, Foxboro Positioner and Limitorque Declutchable Auxiliary Handwheel
8" Heavy Duty Steel Valve with G.P.E. Crank Type Cylinder Actuator

Mason-Neilan offers a broad line of butterfly valves with a choice of nonseating, angle seating, or soft seat wafer bodies and a wide variety of power and manual actuators.

The few typical examples shown here are indicative of the scope of the Masoneilan line. These, and the many other variations available, exemplify the quality and design features resulting from over 75 years of experience in valve manufacturing.

For control of large volumes of liquids or gases, select Masoneilan Butterfly Valves. Complete information on request, ask a Mason-Neilan representative or write to:

MASON-NEILAN

Division of Worthington Corporation

51 NAHATAN STREET, NORWOOD, MASS., U. S. A.

Sales Offices or Distributors in Principal Cities in United States and Abroad

In Canada: Worthington (Canada) Ltd., Mason-Neilan Division

MASONEILAN

MND-38

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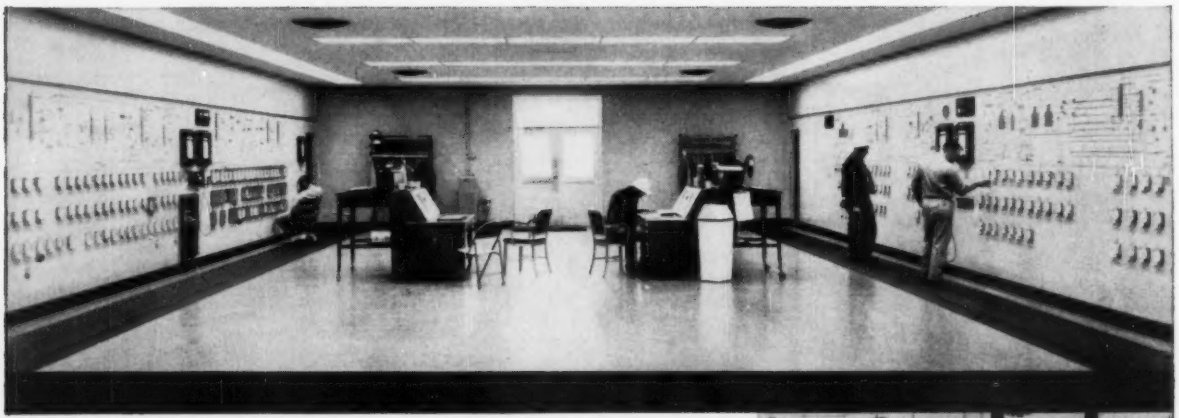
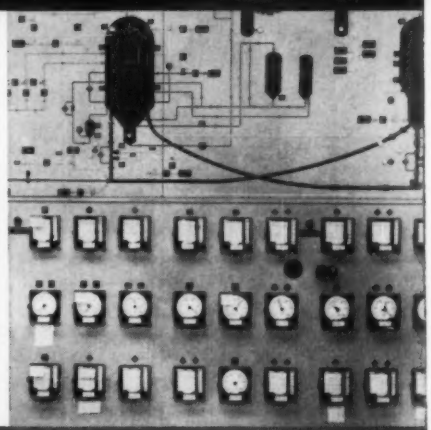


Bristol Metagraphic recorders and indicators occupy lower three rows on panel (shown in two photos above). Enlarged panel section is shown below, right.



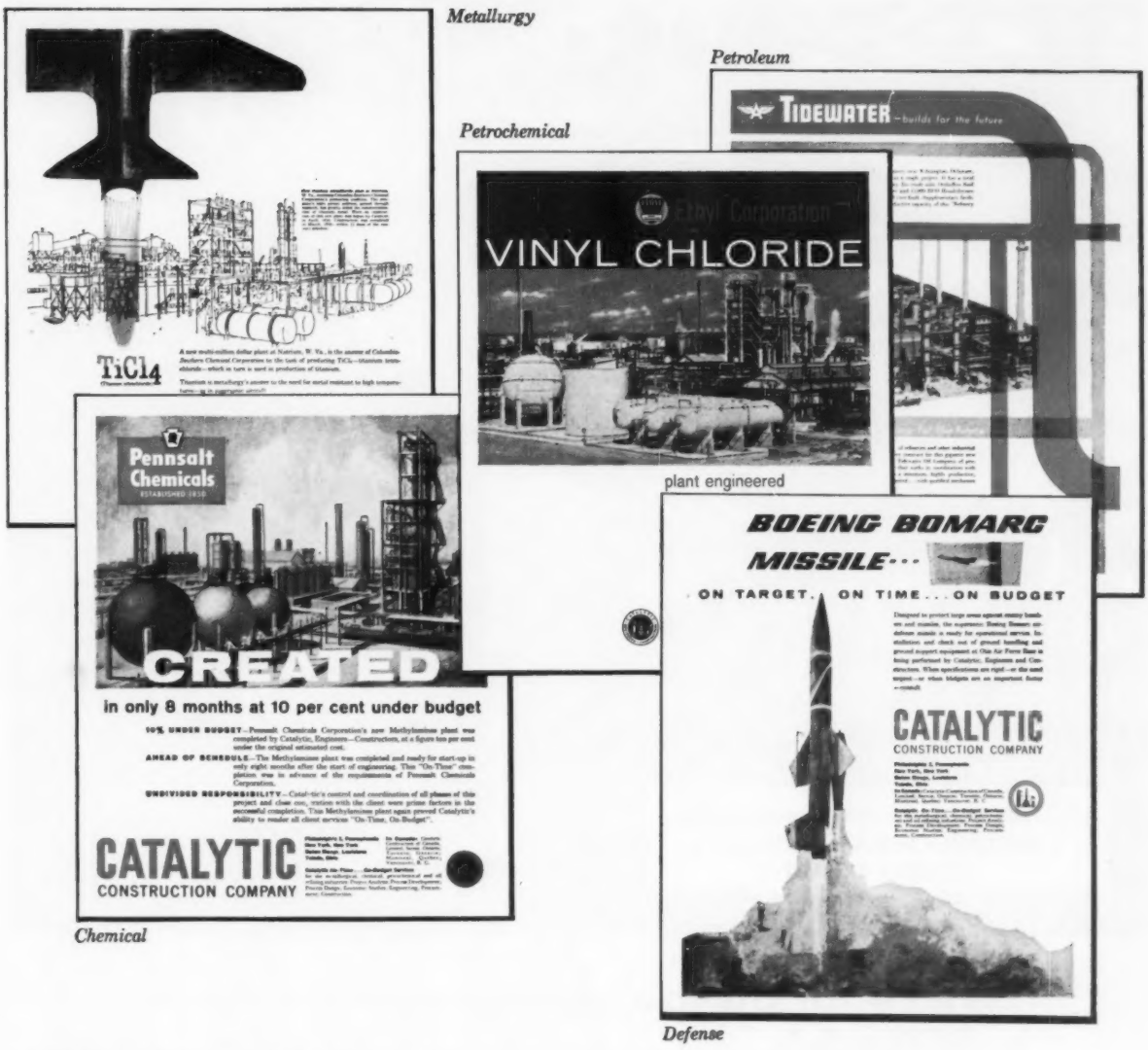
"NERVE CENTER" AT BIG NEW TEXACO PLANT INCLUDES BRISTOL METAGRAPHICS

This model central control room is the nerve center for a vast petroleum processing complex. It's located in the new Puget Sound Works of Texaco Inc., at Anacortes, Washington.

A key feature of the control system is a battery of several hundred Bristol Metagraphic pneumatic recorders, indicators, and controllers (lower three instrument rows on panel). The new plant produces motor gasolines, jet fuels, liquified petroleum gases (LPG), diesel fuel, furnace oil, and heavy fuel oil. Crude oil capacity is 45,000 barrels per calendar day. o.7

BRISTOL ... for improved production through measurement and control
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

This is just one of hundreds of installations of Bristol Metagraphic instruments in use today in processing plants throughout the country. These compact instruments are ideal for graphic panel use, or where true "plug-in" versatility is necessary to insure maximum control system reliability and continuity of service. We'll be glad to send you the complete Metagraphic story. Write: The Bristol Company, 111 Bristol Road, Waterbury 20, Conn.



VERSATILITY... Engineering, construction and maintenance accomplishments in a variety of specialized fields demonstrate the versatile part CATALYTIC plays in today's industry.

Our scope includes complete technical services for the petroleum, petrochemical, chemical, metallurgical, nuclear and defense industries.

Our reputation—"On Time—On Budget."

CATALYTIC

CONSTRUCTION COMPANY
PHILADELPHIA 2, PENNSYLVANIA
In Canada: Catalytic Construction of Canada, Limited; Sarnia, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

We're all on the quality control team at Downingtown Iron Works

Yes, when you place heat exchanger orders with Downingtown, every department of the company contributes to quality construction of the units you need. Every man makes quality control his business—whether he's in sales, engineering, design, purchasing, welding, assembly or inspection. Write for helpful bulletins on heat exchanger design.

UNIT SPECIFICATIONS

Here are specification details for one of the units pictured above:

Size:	72″ diameter by 16′0″ tube length
Tubes:	1406—1¼ O.D. x 12 BWG
Tube Material:	SA213 Grade T-12 (Chrome Moly Steel)
Tube Sheets:	2⅜″ thick SA387 Gr. B Firebox Low Alloy Steel
	2¼″ thick SA212 Gr. B Firebox Carbon Steel
Shell Material:	½″ thick SA387 Gr. B Firebox Low Alloy Steel
	½″ thick SA204 Gr. B Firebox Low Alloy Steel
	½″ thick SA285 Gr. C Firebox Carbon Steel
Baffles:	½″ thick Type 502 Stainless Steel
Expansion Joint:	6′ diameter, triple corrugation, bellows type
Design Conditions:	14 psi @ 1000° Fahrenheit
Weight:	47,000 lb. each

All tubes are seal welded at both ends.

Downingtown Iron Works, Inc.

151 Wallace Ave., Downingtown, Pennsylvania
division of **PRESSED STEEL TANK COMPANY** Milwaukee
Branch offices in principal cities

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more data on advertised products, use Readers' Service Cards, last page.

"A ~~MAN~~ IS KNOWN BY THE *company*

customers it ~~COMPANY HE~~ KEEPS"

Repeat orders are a continual source of pride at Pacific. They indicate the success of our pumps in satisfying the needs of our customers.

Since 1923, Pacific Pumps Inc. has been supplying dependable centrifugal pumps to refineries, chemical plants and similar process installations. Thousands of Pacific process pumps are now contributing to plant efficiency throughout the world.

Pump design and manufacture are not the only features of this enviable performance record. Pacific has a skilled service engineering staff. These men are available when needed... anytime, anywhere.

For complete information about Pacific centrifugal pumps for process service, write to:

PACIFIC PUMPS

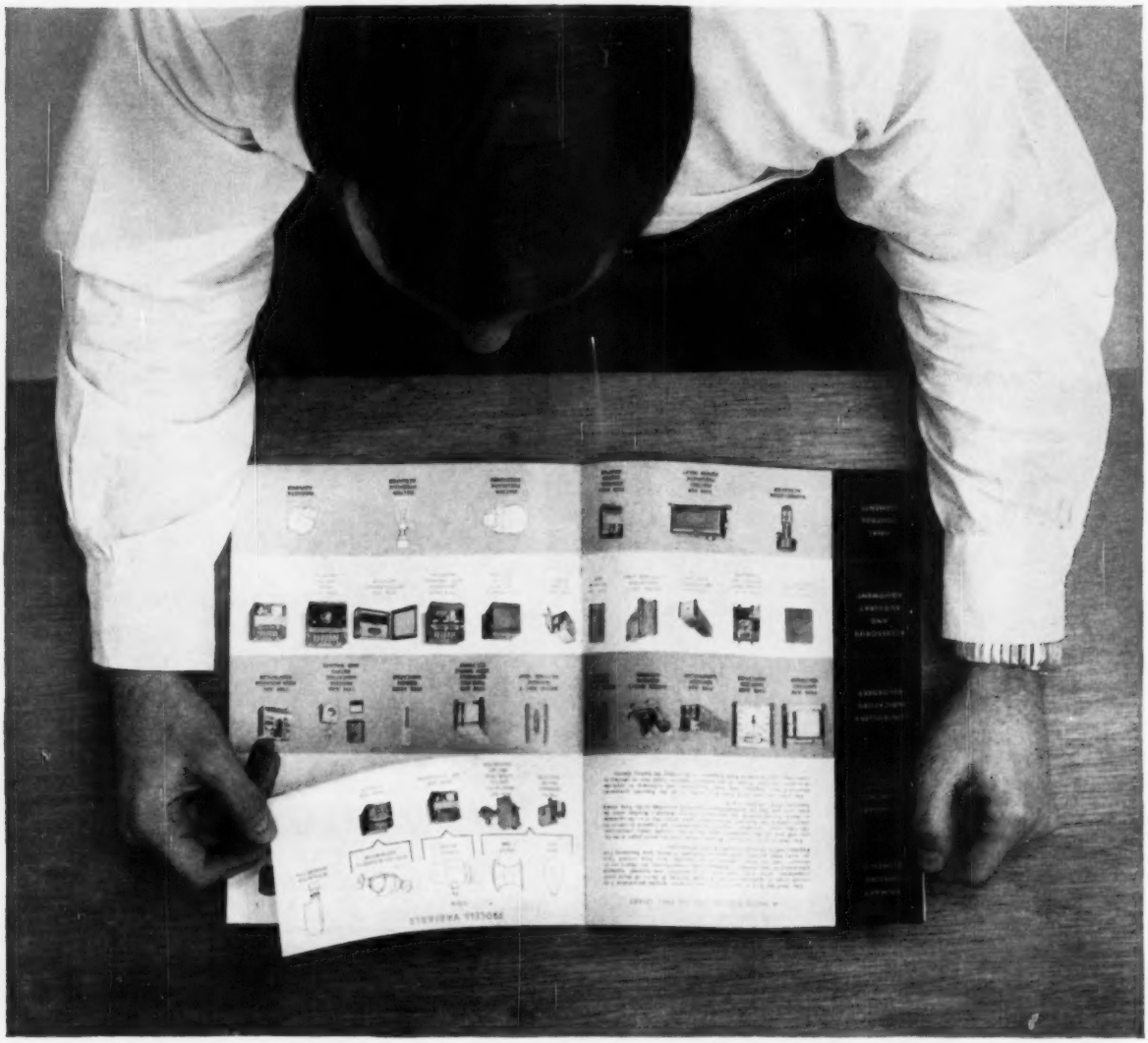
Inc... A Division of Dresser Industries, Inc.

HUNTINGTON PARK, CALIFORNIA

PACIFIC

Offices in all Principal Cities

WHAT'S THE HARDWARE SITUATION IN ELECTRONIC PROCESS CONTROL?



THIS NEW BOOKLET SHOWS YOU

Here, in concise, graphic form, is the whole array of Swartwout Autronic® instrumentation, industry's most comprehensive system of electronic process controls. Here is a unique presentation that shows you at a glance the diversity of equipment available to you, from sensor to actuator, for any given variable. Whether you're pondering a simple flow-control set-up or an interlocked multi-loop system, Swartwout has the hardware for the job—and this booklet will give you the specifics. To get a copy, just write for Bulletin A-913, "A Functional Guide to Autronic Control Equipment." SWARTWOUT DIVISION, CRANE CO., *Hooksett Industrial Park, Manchester, New Hampshire.*

For more data on advertised products, use Readers' Service Cards, last page.

ON THE DAY FIRE STRIKES...

IT'S TOO LATE to check foam liquid for fire-extinguishing performance

IT'S TOO LATE to see if you have enough foam liquid on hand

IT'S TOO LATE to check operation of foam-makers and other foam devices

IT'S TOO LATE to find out whether or not your foam towers work dependably—in a hurry!

but...

it's never too early to make SURE of quality and performance in fire-fighting materials! Insist on proof. That's what you get when you buy from

NATIONAL FOAM SYSTEM, INC. West Chester, Pa.

For more data on advertised products, use Readers' Service Cards, last page.

What you should know about the economics of Reynolds Aluminum Process Pipe

Reynolds Aluminum Process Pipe—strong, lightweight, and corrosion-resistant—costs no more than cold rolled black steel or galvanized steel pipe, when you consider the total installed cost. For example, the table below shows that the base price of Reynolds Aluminum Heavy-End Pipe is almost as low as galvanized steel. Shipping and installation costs for aluminum pipe are invariably lower than heavier pipe—usually from 15 to 30% less.

PIPE COSTS COMPARED

4" Schedule 40 Pipe (Plain End) 100 feet	*Carload Price	Freight to West Texas from Eastern U.S.	Total
Black Steel	98.37	15.86	114.23
Galvanized Steel	117.72	15.86	133.58
Aluminum Heavy End* Alloy 6063-T6	143.75	—(1)	143.75
Aluminum Alloy 6063-T6	179.15	—(1)	179.15
Stainless Steel 304 Schd. 10	621.77	15.86	637.63
Stainless Steel 304 Schd. 40	1065.80	15.86	1081.66

*Quoted as of March 25,1960 (1) Aluminum prices include delivery charges

The table also shows that aluminum pipe is the lowest-cost corrosion-resistant pipe you can buy. Reynolds Aluminum Heavy End Pipe costs about 1/4 as much as stainless 304, Schedule 10, and about 1/7 as much as stainless 304, Schedule 40.

RESISTS CORROSION, WON'T RUST OR CONTAMINATE

The list of corrosive chemicals and process products that aluminum can handle is a long one, and it includes fluids that rapidly corrode other metals. Corrosion-resisting aluminum is ideal for process operations in the chemical, food, beverage, soap, drug, petroleum and petrochemical industries.

LIGHTWEIGHT, BUT STRONG

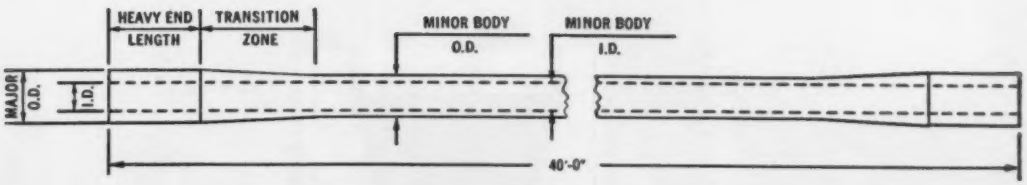
Only one-third as heavy as steel, Reynolds Aluminum Pipe costs less to handle, to ship, and to install. It requires less support, and is easier to move for temporary installations. Yet, aluminum is strong—strong enough to take rough handling and normal operating pressures. In fact, at lower temperatures (down to −320°F) where some metals grow brittle and weak, aluminum is actually *stronger*, with improved tensile and yield strengths, and ductility.

EASY TO WORK, WELD, JOIN

Aluminum is one of the easiest metals to form, bend, cut and join. It welds speedily and securely by any common welding method. You can choose from a large variety of forged and cast aluminum fittings, flanges and couplings for grooved, threaded, and welded joints. This means more design flexibility, lower installation costs. Other unique characteristics of aluminum pipe are also important: It is nonsparking, safer to use with volatiles. And, the smooth inside surface of Reynolds Aluminum Pipe means less danger of scale formation—you get improved product flow that can hold pumping costs down.

AVAILABILITY

Reynolds Aluminum Process Pipe is available in schedules 5, 10, 40 and 80. Diameters range from 1/8" to 12", and thicknesses range from .065" to .200". In addition, Reynolds Aluminum Pipe is available in both Duplex and Heavy-End types.



Reynolds Aluminum Heavy-End Pipe

REYNOLDS DUPLEX PIPE

Reynolds Duplex Pipe is actually a two-pipe steam trace system in one. A dividing wall inside the tube provides two separate channels—one for steam or condensate, the other for the viscuous product. Duplex eliminates an outside steam line and the cost of fastening the two pipes together, and it minimizes insulation needs.

HEAVY-END PIPE

Reynolds Aluminum Heavy-End Pipe can save up to 28% in piping costs. Heavy-End Pipe, with a constant inside diameter, is thicker at the ends to compensate for the loss in mechanical properties due to welding or grooving. Excess metal is eliminated in the pipe body and extra strength is provided where it's needed most—at the joint. It enables you to design a uniformly strong system without paying for extra metal, without overdesigning. Heavy-End Pipe is available in schedule 40 and 80 equivalents, and takes standard fittings.

REYNOLDS—FOR ALUMINUM PIPE, ALUMINUM KNOW-HOW

When designing any process system, plan for economy and long, efficient service; plan with Reynolds Aluminum Process Pipe. For details, contact your local Reynolds office, or write for complete file on the uses of aluminum in the chemical process industry. Use coupon below.

Reynolds Aluminum Duplex Pipe

REYNOLDS ALUMINUM SPECIALTY PIPE DISTRIBUTORS

A. B. Murray Company
P.O. Box 476 • Green Lane • Elizabeth, New Jersey

Boston Pipe & Fittings Company, Inc.
149 Sidney Street • Cambridge, Massachusetts

Gulf Coast Marine Supply Company
Royal and Monroe Streets • P.O. Box 975
Mobile 6, Alabama
and
6985 New Palafox Highway • P.O. Box 2127
Pensacola, Florida

Industrial Piping Supply Co.
1501 Dowd Rd. • P.O. Box 10218 • Charlotte, N.C.

McJunkin Corporation
P.O. Box 513 • Charleston 22, West Virginia

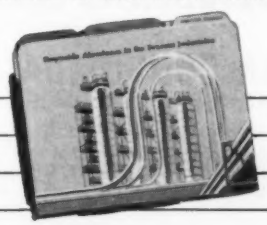
Piping Products Company, Inc.
Church Street and West Central Ave.
Moorestown, New Jersey

Horace T. Potts Company
Erie Avenue and "D" Streets
Philadelphia 34, Pennsylvania

Watch Reynolds TV shows: "ADVENTURES IN PARADISE," "BOURBON STREET BEAT" and "ALL STAR GOLF"—ABC-TV.

REYNOLDS ALUMINUM

WRITE FOR REYNOLDS DATA FILE
Aluminum for Chemical Process Uses



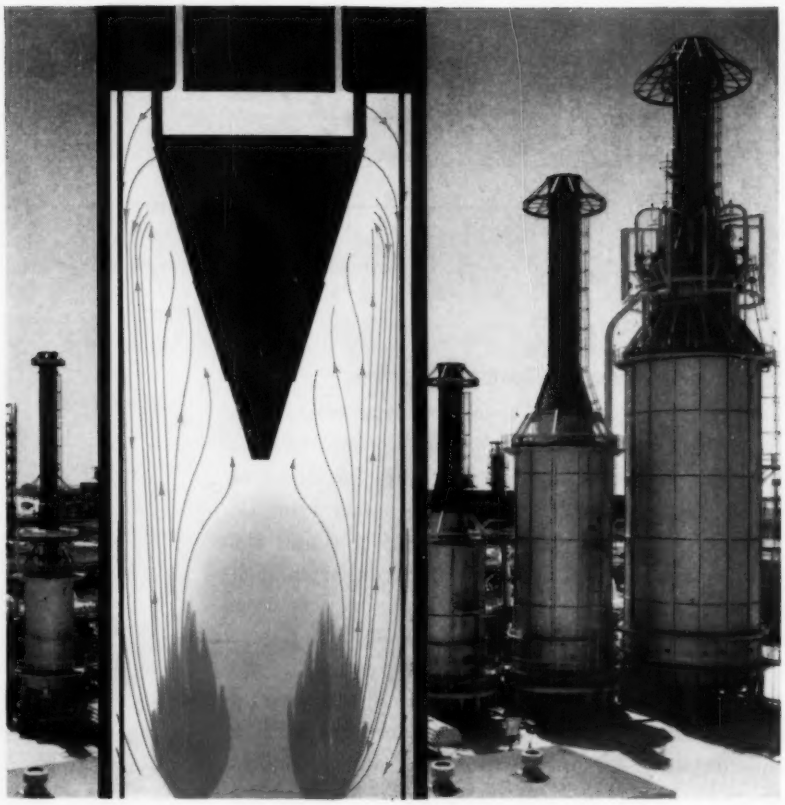
Reynolds Metals Company
P.O. Box 2346-CT • Richmond 18, Virginia

Please send me your free data file on Aluminum for Chemical Process Applications.

*Name*_____
*Company*_____
*Address*_____
*City*_____ *Zone*____ *State*_____

For more data on advertised products, use Readers' Service Cards, last page.

PUTTING THE HEAT ON EVENLY EFFICIENTLY



Petrochem Isoflow Furnaces give even heat distribution—with added convection sections for maximum fuel efficiency

This is the heart of Petrochem Isoflow Furnaces—the furnaces that get more heat from every measure of fuel. Only Petrochem incorporates all three critical design features so important to highest efficiency in fired heaters: 1) burners specifically designed to furnace needs, 2) properly engineered firebox proportions, and 3) reradiation cones. These factors add up to a more even heat distribution and maximum heat efficiency. Even greater heat efficiency for certain heater applications can be obtained with Petrochem's added convection sections.

Cleaning is easier than with ordinary horizontal-type heaters. Only 25 per cent of the space normally needed is required to pull the tubes of a Petrochem furnace. When specifying furnaces—remember, *there are more Petrochem Isoflow Furnaces in service today than any other make.*

YUBA

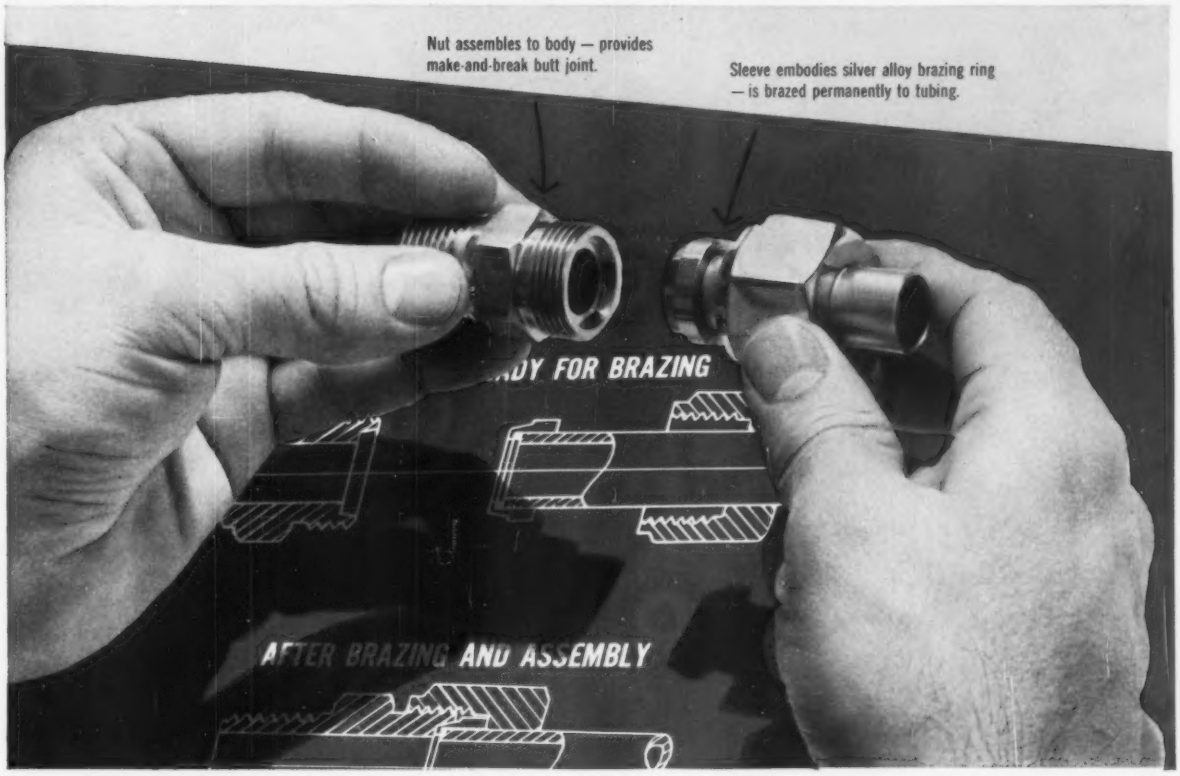
specialists in process furnaces for every size, capacity and duty

PETROCHEM DEVELOPMENT DIVISION
6700 Liberty Road, Houston, Texas

YUBA CONSOLIDATED INDUSTRIES, INC.

REPRESENTATIVES: Faville-LeVally Corp., Chicago • Flagg, Brackett & Durgin, Inc., Boston • D. D. Foster Co., Pittsburgh • William H. Mason Co., Tulsa • Lester Oberholtz Assocs., Los Angeles • Rawson-Houlihan Co., Inc., Houston • Rawson Co., Inc., Baton Rouge • Rittelmeyer & Co., Atlanta • H. W. Severance, Prospect, Ky. • Turbex Equipment Co., Narberth, Pa. G. M. Wallace & Co., Denver, El Paso & Salt Lake City • Combustion & Power Equipment Ltd., Montreal & Toronto • International Licensees and Representatives: Birwelco Ltd., Birmingham, England • Fujinagata Shipbuilding Ltd., Osaka, Japan • Heurty Italiana, S.P.A., Milan, Italy • Petrochem, G.M.B.H., Dusseldorf, Germany SETEA S.A., Buenos Aires, Argentina • Societe Anonyme Heurtey, Paris, France • Societe Anonyme Belge Heurtey, Liege, Belgium.

IMPERIAL
Engineering and Data File


Nut assembles to body — provides make-and-break butt joint.
Sleeve embodies silver alloy brazing ring — is brazed permanently to tubing.
DY FOR BRAZING
AFTER BRAZING AND ASSEMBLY

NEW BRAZE-SEAL TUBE FITTING

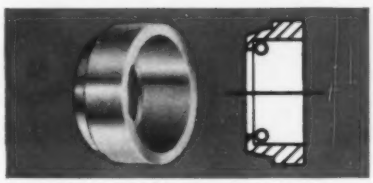
WITHSTANDS SUPER-PRESSURES, HIGH TEMPERATURES . . . RETAINS MAKE-AND-BREAK CONVENIENCE

Until Imperial Braze-Seal came along, engineers could not specify an economical make-and-break fitting for tubing circuits involving super-pressures and high temperatures. Applications like these called for welded connections. But now Braze-Seal offers high reliability, even under extreme pressures. (See chart below.)

MAXIMUM DESIGN PRESSURES (PSI) FOR BRAZE-SEAL FITTINGS

Tube O.D.	316 Stainless	Carbon Steel
3/8"	64,000	48,000
1/2"	62,400	46,800
9/16"	61,600	
5/8"	61,600	46,200
3/4"	60,000	45,000
7/8"	56,000	42,000
1"	52,000	39,000
1-1/4"	48,000	36,000
1-1/2"	44,000	33,000

Application of the following safety factor is recommended: 4 to 1, for sizes up to ⅝" O.D.; 6 to 1, for sizes ¾" to 1½" O.D.



This Braze-Seal Sleeve, containing a silver alloy brazing ring, is the key to the performance of the Braze-Seal Fitting. It assures a joint that will withstand these extreme pressures because it is permanently brazed to tubing. Yet the fitting provides the convenience of a make-and-break butt joint, as illustrated, and is extremely easy to assemble.

Reducing Sleeves Provide Versatility

Can be furnished to reduce any size Braze-Seal tube end to any specified tube size. Extremely convenient on tees, for example, where any size tubing can be connected to the same tee body. Also, the same body may be used for making up flareless Hi-Seal fitting joints.

Imperial Braze-Seal Tube Fittings can be furnished in steel or stainless steel.

Check the outstanding features of Braze-Seal for yourself. Send for a sample fitting. See how Braze-Seal can help you solve the most difficult problems in super-pressure and high-temperature tube circuitry.

IT'S IN THE BOOK

Braze-Seal Fittings are covered in Imperial's new Hi-Seal Catalog — the most comprehensive coverage available on the subject of fittings, a hard-working handbook for engineers. Send for your copy today.

THE IMPERIAL BRASS MANUFACTURING CO.
Dept PR-50, 6300 West Howard Street
Chicago 48, Illinois

8-60

For more data on advertised products, use Readers' Service Cards, last page.

COPPUS BLUE RIBBON PRODUCTS

Coppus Steam Turbine with Built-In Speed Reducer

STAMINA — You can literally *see* stamina in every dimension of a Coppus Turbine . . . rugged reliability that assures you stable, positive performance. It truly "wins" the Blue Ribbon with which it is marked . . . through advanced design, top quality materials, and thorough testing. With Coppus you're always certain of Blue Ribbon features such as these —

A totally enclosed governor . . . totally enclosed, independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. Sizes from 1 HP to 250 HP. All Coppus Products carry the same Blue Ribbon assurance of reliable performance. For further facts on turbines, send for new Catalog 200. COPPUS ENGINEERING CORPORATION, 415 Park Ave., Worcester, Mass. Sales Offices in *Thomas' Register*.

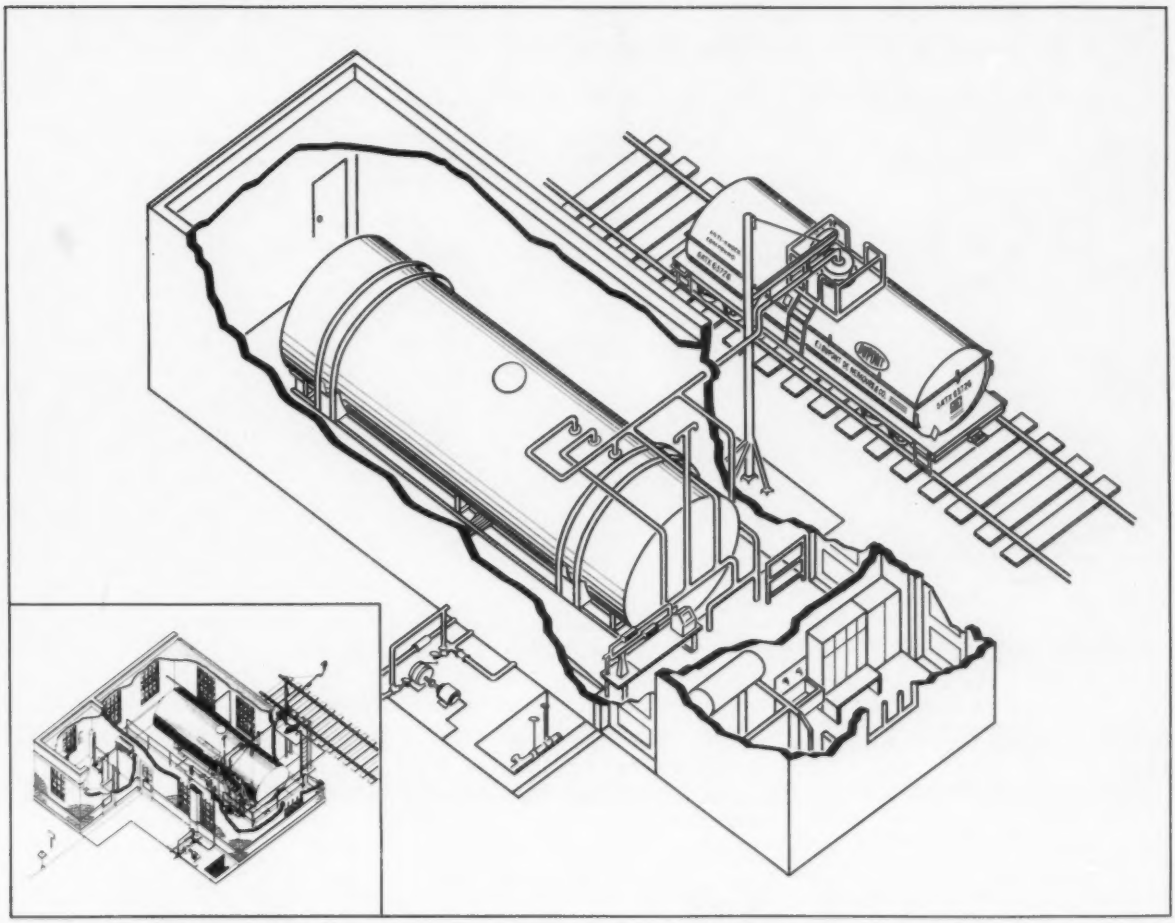
COPPUS
STEAM TURBINES

DU PONT *Petroleum Chemicals* NEWS

Number 102 in a Series of Bulletins for the Petroleum Industry

MAY-JUNE 1960

New TEL blending plant design puts more efficiency into less space



NEW TETRAETHYL LEAD BLENDING PLANT represents a major design change made possible by Du Pont's continuing efforts to develop new methods for more efficient use of petroleum additives by refiners.

Du Pont design reduces unloading time, cuts construction and maintenance costs

Ever since Du Pont designed the first tank-car-to-weigh-tank tetraethyl lead blending plant in 1928, our continuing research programs have yielded many refinements in blending plant equipment and operation. Among them have been the metal-flex unloading hose, the siphon starter and hydraulic system modifications.

Du Pont engineers have now figuratively taken apart and redesigned the TEL blending plant from the ground up. Their goal was to develop a design that incorporates new engineering developments and materials.

They tested valves, fittings and components to determine their actual interrelations. They evaluated the relationship of tank car and weigh tank. They investigated construction costs. They accumulated mountains of facts and details.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT *Petroleum Chemicals* NEWS

Railroad learns what happens when it stops using FOA-2

Not long ago, a leading railroad tried an interesting experiment:

They had been using Du Pont FOA-2 to keep diesel locomotives free from filter plugging and other potential fuel problems. At one point, however, they felt that the sludge problem wasn't severe enough to justify continued use of the additive. So they discontinued use of FOA-2 in certain fuels, to measure its value.

Shortly after the test started several cases of fuel incompatibility were reported for the first time; filter plugging increased; and it was quickly found that the cost to replace the filters was more than the cost of the FOA-2 they had previously used.

Today, this railroad is once more using FOA-2 to reduce sludging and keep filters clear. Costs and maintenance and worries are once more back in line.

Du Pont AFA-1 provides economical corrosion protection for Aviation Fuels

Refiners are reminded of the very high effectiveness of Du Pont AFA-1 Aviation Fuel Additive as a corrosion inhibitor.

Concentrations as low as 2-4 pounds per 1,000 gallons have been found to produce rust inhibition in some fuels by the modified ASTM D665-54 Dynamic Rust Test.

Exact dosages, of course, depend upon the characteristics of the fuel itself. But the consistently low amounts of AFA-1 required can mean substantial savings in your additives costs. (Another advantage of AFA-1: the water tolerance test on aviation gasolines as jet fuels is more easily met.)

In addition to automotive and aviation gasolines, Du Pont AFA-1 brings the advantages of corrosion inhibition to other petroleum products such as heating oils and diesel fuels. Contact your Du Pont Petroleum Chemicals representative for additional information. Ask for our bulletin on Du Pont AFA-1.

CONTINUED

Plant redesign

Mathematical Model

From these data, a mathematical model was built which could be modified at will and examined by computers. The Univac then translated these models into actual blending plant designs. For any prospective design, for example, Univac could evaluate such data as specific gravity of the fluid, viscosity, barometric pressure and initial vacuum to determine unloading time. Optimum performance values were then established.

The result: an updated lead blending plant design that:

Reduces unloading time because every valve and fitting is operating at its known, optimum capacity. The operator's effort is reduced as well, since his work area is now at the *end* of weigh tank. Waste motion is eliminated.

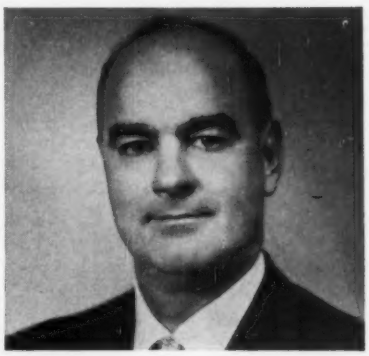
Reduces construction costs through a more compact, modern design. The "straight-line" plant occupies less floor area, eliminates windows and the former "L" floor plan. With the weigh tank installed on the scale, several tons of structural steel supports are eliminated.

Reduces maintenance, for example, through a new ball valve design which provides for low pressure drop. This valve is equipped to minimize leakage and packing problems.

Full Details Available

Interested refiners can obtain full details on this new blending plant design by contacting the nearest Du Pont Petroleum Chemicals representative. His office is listed in the box below.

You ought to know



LEWIS Z. CAREY, manager of our Pittsburgh district office. He succeeded the late Afton D. Puckett in mid-1959.

A native Philadelphian and a graduate of the University of Delaware, Lew Carey first came to Du Pont in 1941 when he joined the Organic Chemicals Department. Later that year he began four years of military service as gunnery officer aboard a destroyer escort.

He returned to Du Pont late in 1945 and was a sales correspondent for our Alcohol and Camphor Division until 1951, when he joined the operations section of the Petroleum Chemicals Division as a technical assistant. Shortly afterward he became a sales service representative in our Eastern region, and then became the first manager of our Philadelphia district office in 1955. In that assignment, he was effective in serving the petroleum refiners and marketers in that area with the technical, marketing and refining know-how of Du Pont's Petroleum Chemicals Division.

SALES OFFICES

Chicago 3—8 So. Michigan Ave.	RAndolph 6-8630
Cleveland 15—101 Prospect Ave.	MAin 1-3422
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New York 20—45 Rockefeller Plaza	COlumbus 5-2342
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San Francisco 4—111 Sutter St.	EXbrook 2-1934
Seattle 3—4003 Aurora Ave.	MElrose 2-6977
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In Canada—Du Pont of Canada Limited, Petroleum Chemicals, 85 Eglinton Ave. East, **Toronto 12,** Ontario	HUdson 1-6461
OTHER COUNTRIES: Petroleum Chemicals Division, Export Sales, Wilmington 98, Delaware	PRospect 4-2962

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Better Things for Better Living
. . . through Chemistry

Du Pont Tetraethyl Lead and other Petroleum Additives

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-14686

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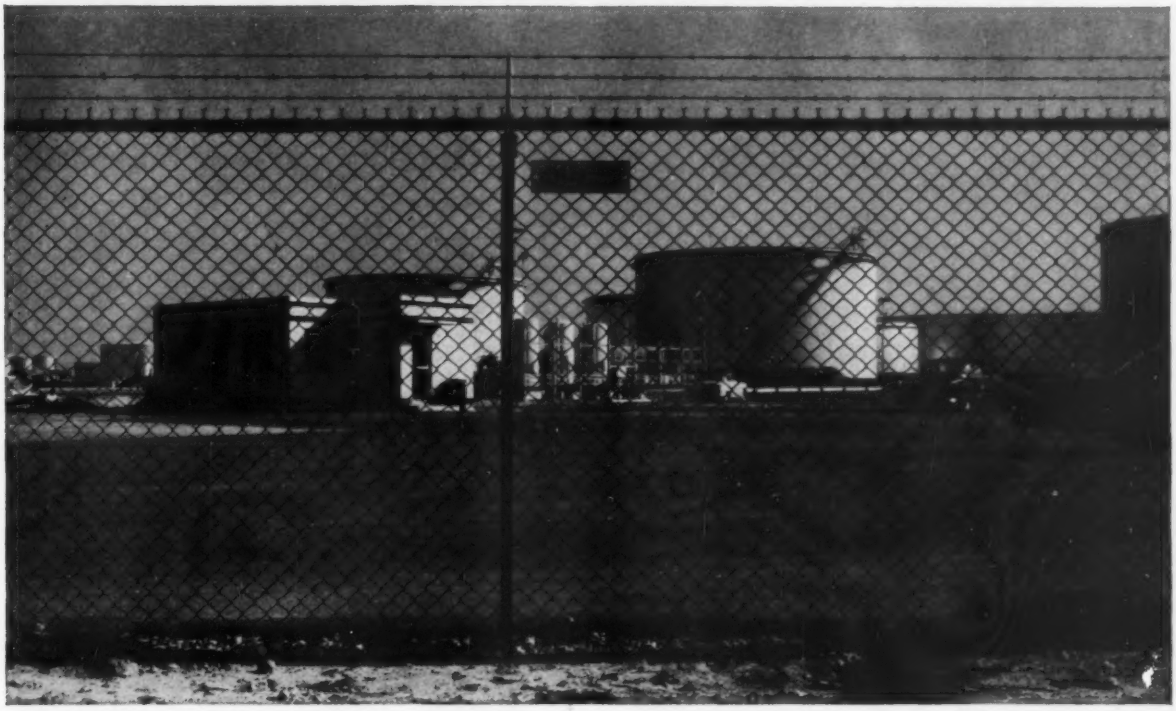
Specially engineered gates. Every Cyclone gate is just as sturdy, durable and non-climbable as the rest of the fence. They're mounted on heavy posts . . . equipped with solid hinges and catches . . . and have the closest precision in the locking device.



USS Cyclone Steel Fence keeps your private property private

Thieves, vandals and trespassers know better than to try getting past a USS Cyclone Steel Fence. This rugged, 24-hour watchman protects valuable property and equipment as no *human* watchman can. Cyclone also keeps children from playing on the premises . . . averts possible damage suits resulting from accidents. It's tough, strong, fire- and corrosion-resistant—built to stand indefinitely with very little maintenance. USS Cyclone Steel Fence will keep *your* private property private. Write to American Steel & Wire, Dept. 0243, 614 Superior Avenue, N.W., Cleveland 13, Ohio.

USS and Cyclone are registered trademarks

Where security counts, count on USS Cyclone Fence

American Steel & Wire Division of United States Steel

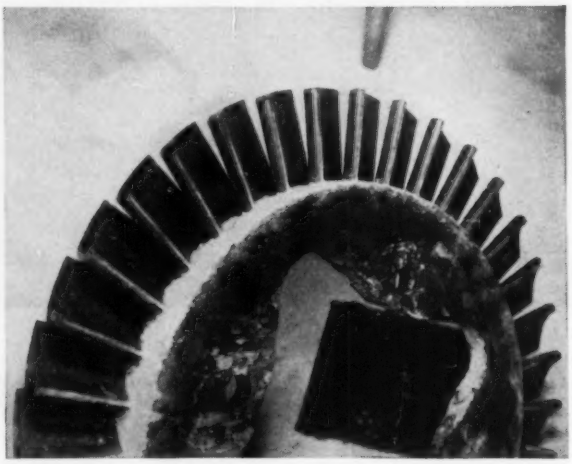
Cyclone sales offices coast to coast

For more data on advertised products, use Readers' Service Cards, last page.

NEW SHELL POWER RECOVERY PROCESS CUTS CRACKING COSTS

Shell now offers a way to run power recovery turbines on waste energy. The key to this process is a simple, effective fines separator that protects gas turbine blades to obtain long turbine life. Look at these unretouched photographs.

WITHOUT SHELL PROCESS—Turbine nozzle blades after only 650 hours of operation.



WITH SHELL PROCESS—After 4000 hours of operation.

The use of this Shell-designed fines separator with existing fluid-bed cat cracker regenerators permits the inexpensive expansion of carbon-burning capacity. In new systems it is capable of making substantial savings on your steam or power requirements. The process is licensed by Shell and through authorized contractors. Inquiries are invited. Shell Development Company, 50 West 50 Street, New York 20, New York.

SHELL DEVELOPMENT COMPANY

SHELL

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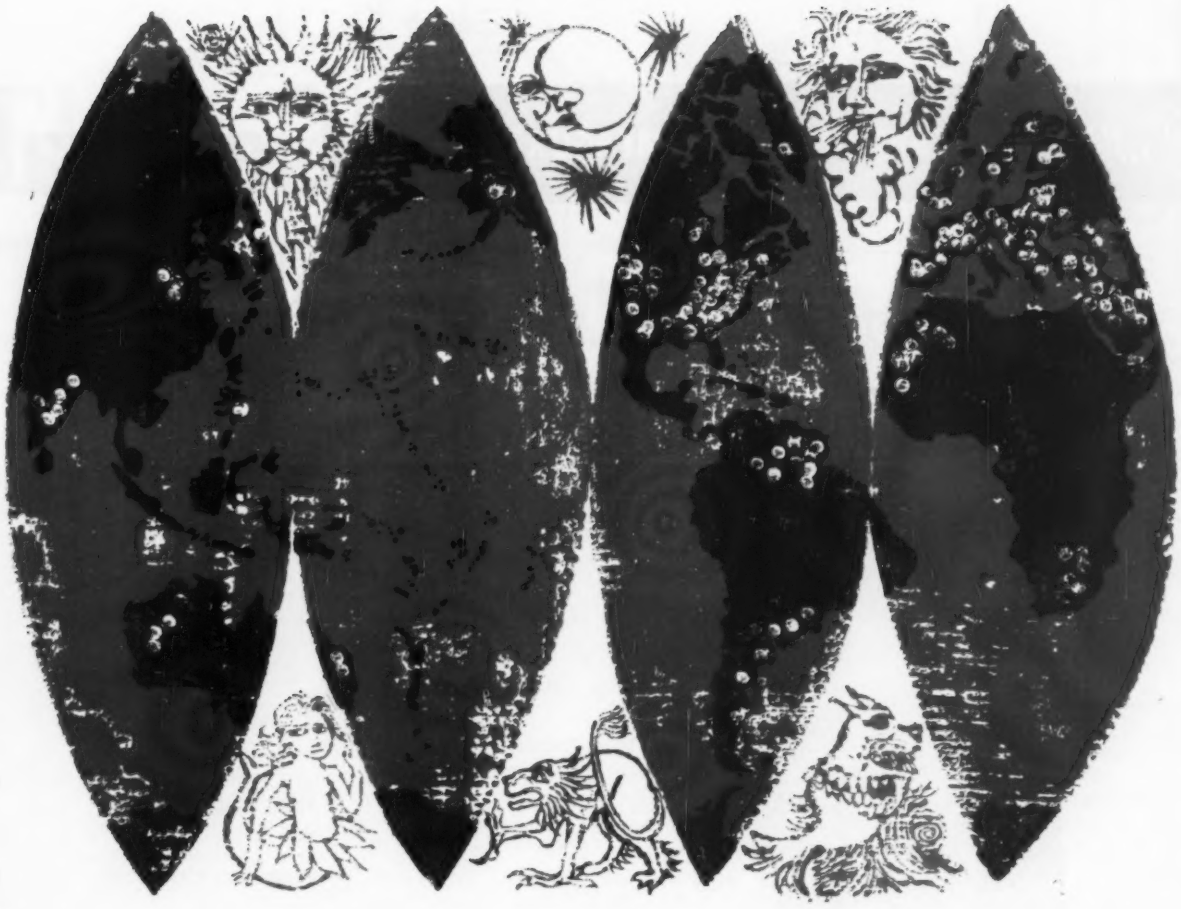

805 reasons a Foster Wheeler plant fits your requirements best

Wouldn't you like to find your new plant running on its scheduled completion date, meeting all specifications, and at a cost within the construction budget? The process industries have come to expect results like these when dealing with Foster Wheeler.

Would you like to see your own process plants handled by designers, engineers and construction men who have successfully put 75 different processes into efficient commercial operation?

And, if you have decided to pioneer a new process, wouldn't you like to have the advantage of Foster Wheeler's long experience with basic processing methods, such as fluidized solids, effluent refrigeration, simplified sulfonation, and efficient heat balancing in chemical operations, etc. This unique experience—plus *procurement knowledge* gained in construction of some 805 large and small plants throughout the world, and *specialized equipment know-how* available through FW's own equipment division—works for you when you use FW design, engineering and construction services.

Get specific information by discussing your process needs and plant requirements with Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N.Y.—or write for a copy of the new fully-illustrated booklet describing FW's services.

Heat Engineered products, plants and processes...for the world's industrial progress.

FOSTER WHEELER

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petroleum processing

chemical processing

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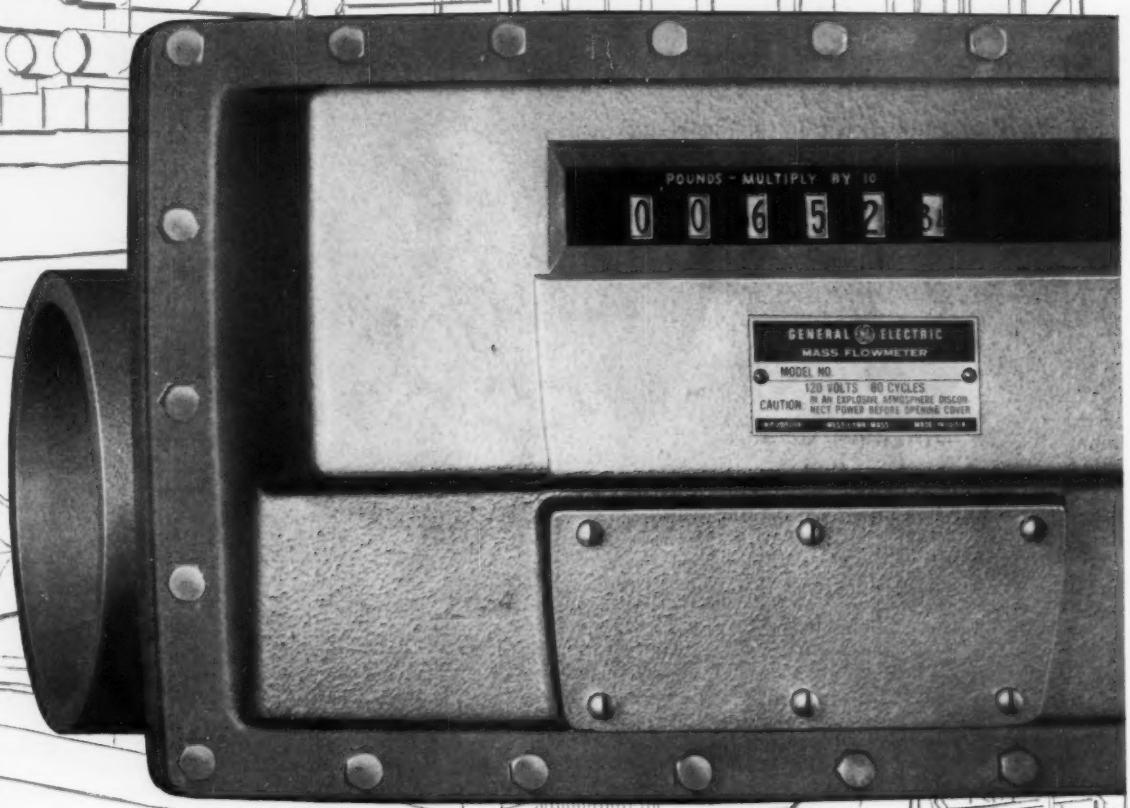
NEW CONCEPT IN FLUID MEASUREMENT

General



Electric Gyro-Integrating True Mass Flowmeter

ACCURATELY MEASURES FLOW OF LIQUIDS, GASES AND LIQUEFIED GASES . . . DIRECTLY IN POUNDS

This new General Electric meter provides continuous local or remote totalization and registration of gas and liquid flow by weight within ±1 percent accuracy over wide variations in flow rate, density, pressure, temperature and viscosity.

PROCESS FLOW MEASUREMENT—Ideal for applications in the petroleum, chemical, and petro-chemical industries, the new mass flowmeter completely eliminates time-consuming orifice calculations and possible costly errors in correcting volumetric readings for fluid variables. It does away with the need for recalibration when process and flow conditions change, too. And it puts an end to supercompressibility problems.

What's more, the new flowmeter lets you make complete and accurate material balances easily because it operates on a mass measurement principle and gives you your answer *in pounds*. No more measuring liquids in gallons or barrels, gases in cubic feet, then making tedious conversions in order to equate the two. Measurement of both by weight allows direct comparison.

LIQUEFIED GAS MEASUREMENT—You can measure the weight of truck and tank car loading of your liquefied gas products easier and faster with General Electric's new mass flowmeter than with present volumetric-type meters or expensive and cumbersome scale installations. The meter registers the total loaded weight directly in pounds. Then, operating from a battery-inverter power supply, the flowmeter can be used right on your truck when unloading, for easy and accurate deliveries. And no precautions are necessary to protect the meter from high velocity caused by "flashing."

An outgrowth of General Electric research into mass flow measurement, this new meter has already been proved on such fluids as natural gas, ethylene, Freon, liquid carbon dioxide, naphtha and jet fuel.

For complete sales and service information, contact your nearby General Electric Apparatus Sales Office, or write for bulletin GEA-6925A, Section 599-02, General Electric Company, Schenectady 5, N. Y. On applications in the natural gas industry, contact Black, Sivalls and Bryson, Inc., Kansas City, Missouri.

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INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

sharp

AMERICAN BI-METAL THERMOMETERS make accurate temperature readings sharp and sure at all check points

American Dial Thermometers are also available in mercury, vapor pressure, and gas actuation . . . on-the-spot and distant reading types . . . in sizes, ranges and stem lengths to meet your most exacting requirements.

sensitive

Any way you look at an American Bi-Metal Thermometer, you see exact working temperatures.

The two-level "Maxivision®" dial eliminates parallax effects. Numerals are on the lower level. Graduations are on the outer raised ring dial which presents a sheared edge to the tip of the pointer and in the same plane. To make readability even more accurate, the glass and graduated dial are closely spaced.

American Bi-Metal Thermometers are made of weather-proof stainless steel. All joints are welded to solid unity, then polished smooth so corrosion won't build up and destroy the thermometer's usefulness. And, you don't have to discard this thermometer even if the glass is ever broken. The bayonet lock bezel makes replacement easy.

Learn about the high sustained accuracy and long service life built into American Bi-Metal Thermometers. Phone your nearby industrial supply distributor for help in selecting the right type for each temperature check point in your plant. Or write for Catalog 100A.

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

AMERICAN INDUSTRIAL THERMOMETERS

A product of

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Gauge and Instrument Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

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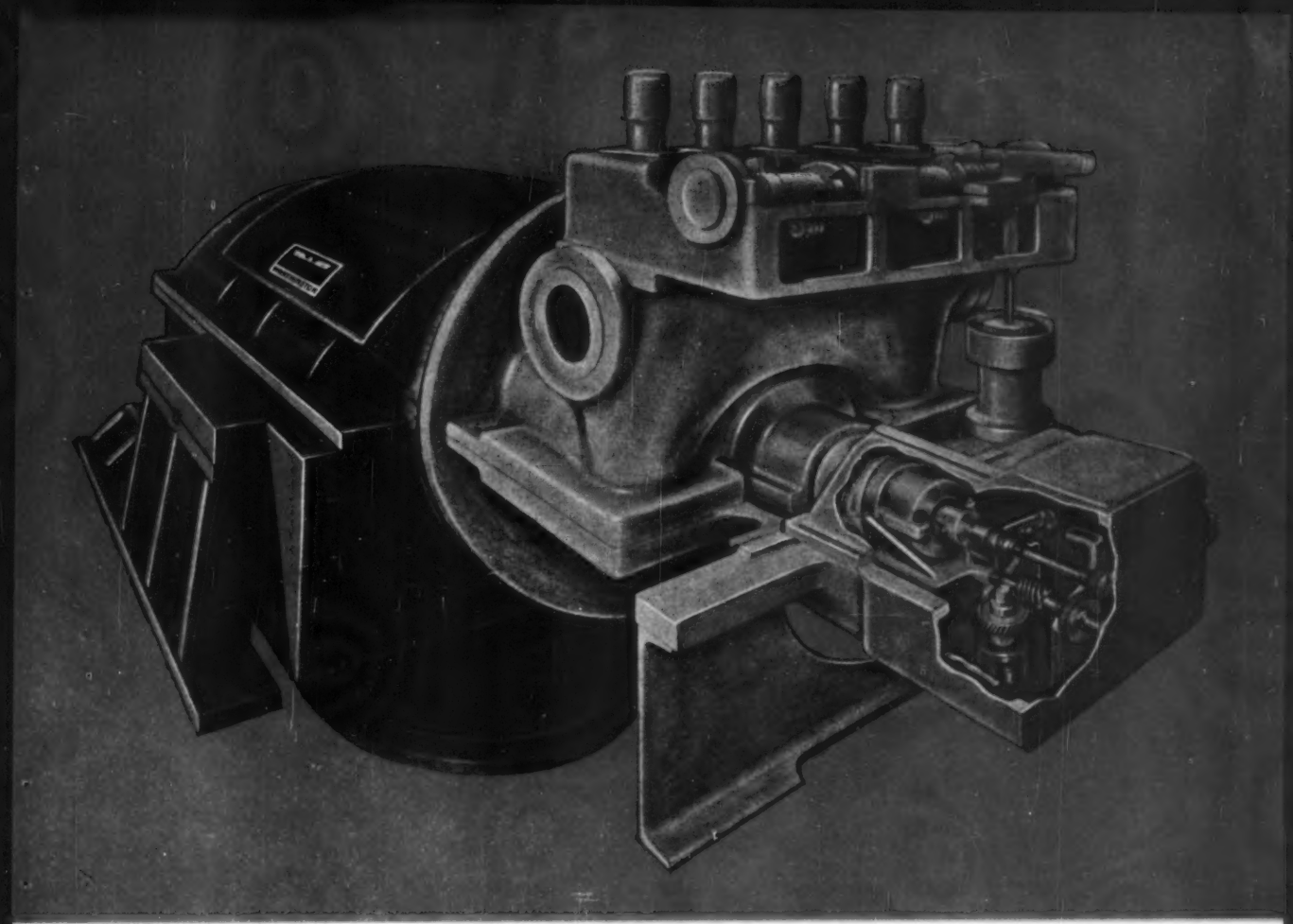
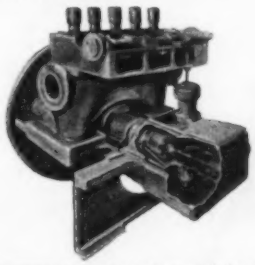
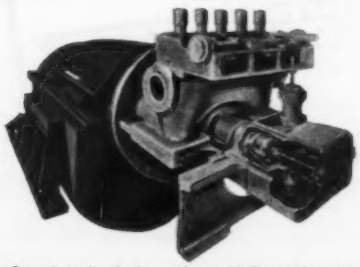


HOW WE ASSURE RELIABILITY IN A NEW DESIGN

1. Use an existing high-speed bearing case and a high capacity thrust bearing.



2. Add a high-pressure steam end of proved design with cam operated automatic nozzle control valves.



3. Complete the design with a multi-flow exhaust end.

HOW TO BUILD THE WORLD'S FASTEST 10,000 HP TURBINE

You can order this trail-blazing 15,000 rpm centrifugal compressor-drive turbine today with complete confidence because it makes use of components of proved reliability

Progress without sacrificing reliability is the goal of Worthington's Steam Turbine Division. How Worthington's creative engineering and advanced planning works to your advantage is illustrated by the steps taken in the continuing development of turbines of increasingly higher speeds:

1. Wherever possible use existing components proved reliable by years of operation.
2. Modify designs already in use in other high speed applications.
3. Thoroughly test these modifications to prove their reliability before field application.

Such advances in the turbine art bring new economies to high-speed, high-horsepower compressor drive applications. For information, call your nearest Worthington district office or write Worthington Corporation, Section 48-9, Wellsville, New York.

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FORGED STEEL
valves

NEW ENGLAND VALVE CORPORATION

Box 1047 • Worcester, Massachusetts • PLeasant 4-1781

We are glad to announce that the complete line of SMITH Forged Steel Valves for the Refining, Chemical and Petrochemical Industries is now available in the Gulf area. For quick and dependable service on SMITH Gates, Globes and Needle Valves, please order from . . .

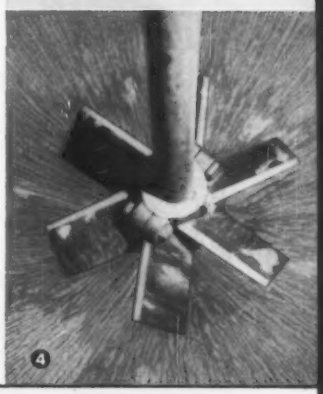
Improved Processing through Engineered Agitation

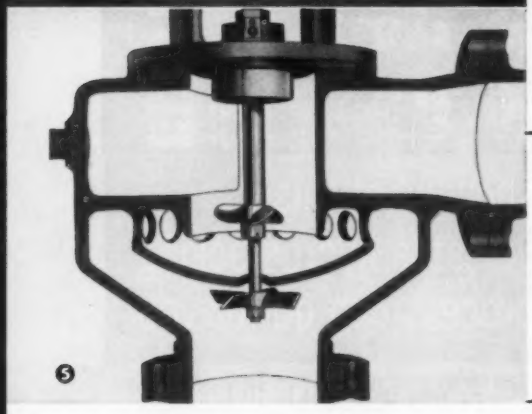
IMPELLER SELECTION . . . THE INSIDE STORY OF GOOD MIXING

THE DESIGN AND PERFORMANCE OF THE IMPELLERS are major factors in the success of process mixers. Determining the right impeller requires a thorough knowledge of below-the-surface action of different impellers in a wide variety of fluids of different density and temperatures.

THROUGH CONTINUOUS RESEARCH AND EXPERIENCE . . . gained in thousands of pilot runs and working installations . . . NETTCO has acquired the impeller know-how so important to efficient mixing. And this below-the-surface know-how can cut your processing costs by minimizing horsepower requirements!

YOUR NETTCO REPRESENTATIVE CAN HELP YOU make your process more efficient . . . more profitable. See Chemical Engineering Catalog or Refinery Catalog for his address or write for Bulletin 581. NETTCO Corporation, 81 Tileston St., Everett 49, Mass.

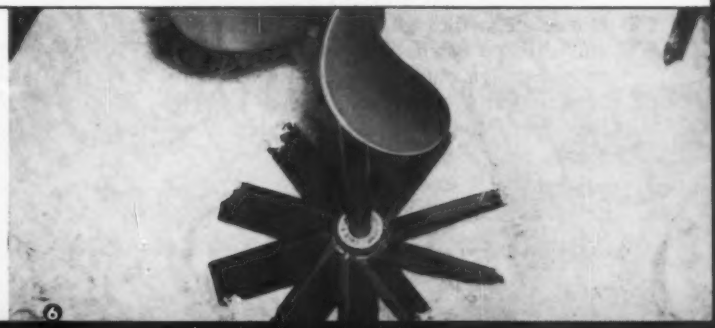




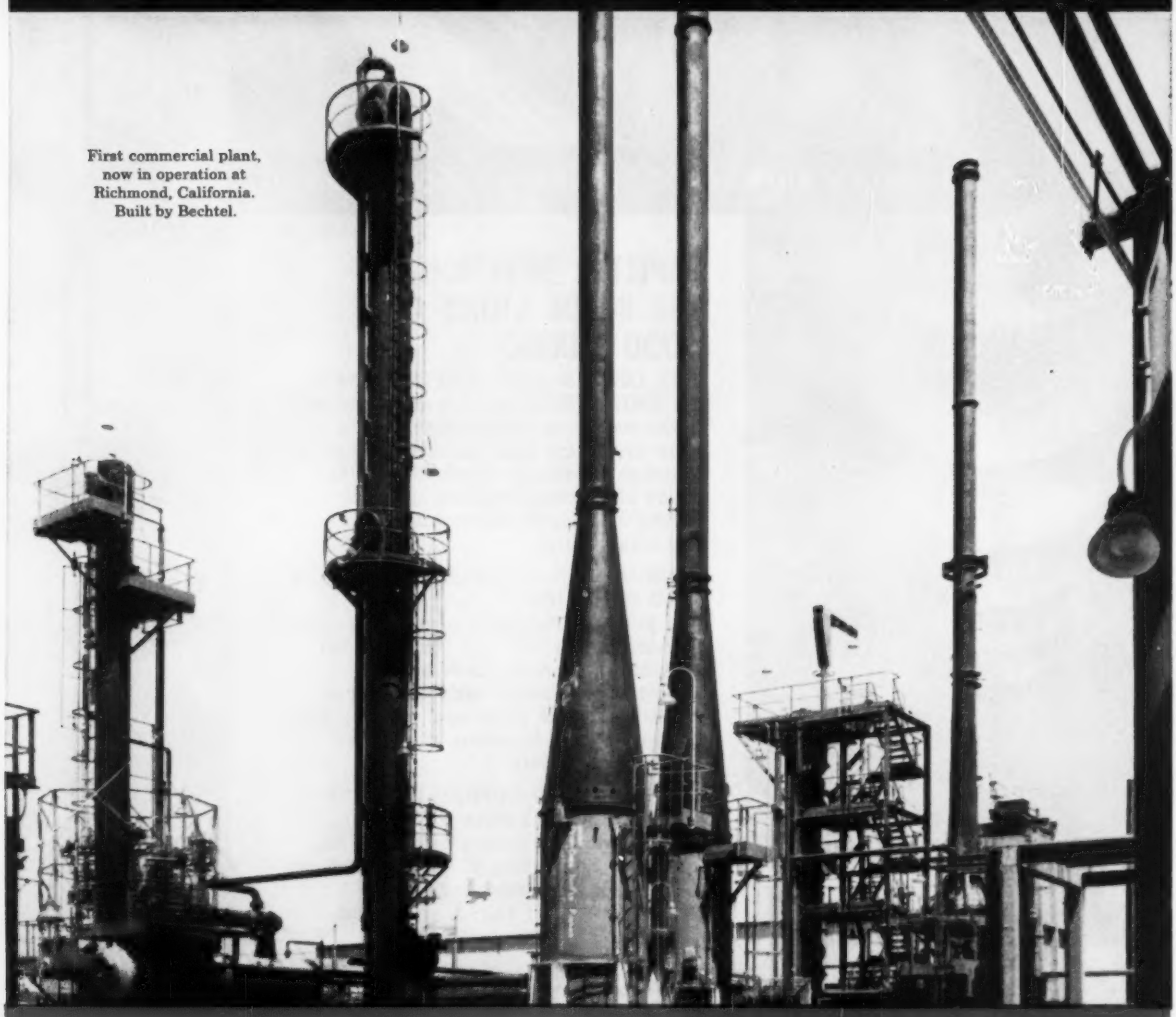
NETTCO

ENGINEERED AGITATION SPECIALISTS
EVERETT 49, MASSACHUSETTS

1. Vertical finger and breaker stirrers used in the dispersion of high viscosity materials.
2. Medium speed propeller recommended for medium size batch mixing of low viscosity material.
3. Corrosion-proof, plastic covered flight impeller which automatically provides variable agitation for variable tank volumes.
4. Split turbine stirrer designed for pressure tanks where minimum tank opening size is necessary.
5. Flomix impellers for continuous pipe line mixing of solids and medium to low viscosity material.
6. Standard turbine and propeller combination provides vigorous agitation for solid suspension, heat transfer and blending.



ISOCRACKING*



First commercial plant, now in operation at Richmond, California. Built by Bechtel.

LET BECHTEL show what this versatile hydrocracking process can do for you

ISOCRACKING PLANTS are available immediately through Bechtel Corporation and affiliated Bechtel companies—licensed to process design, engineer and construct plants employing this advanced new technique by its owners and developers, California Research Corporation.

Your inquiry is invited.

BECHTEL CORPORATION

Engineers and Builders for Industry

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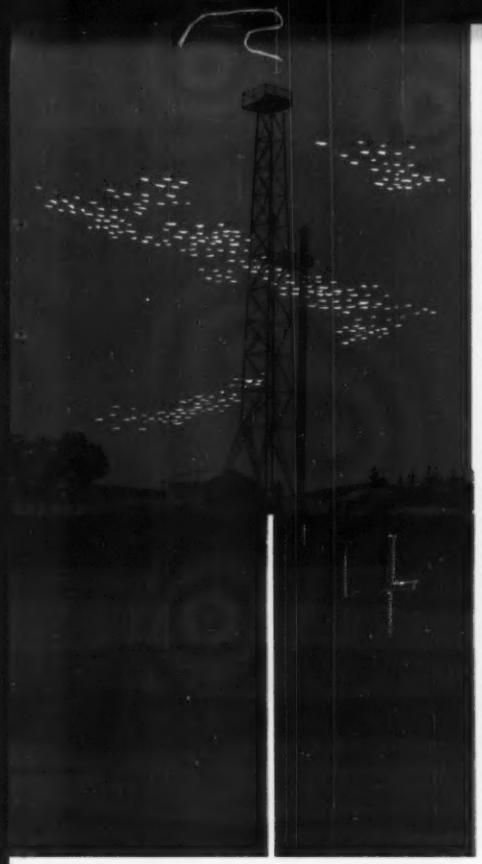
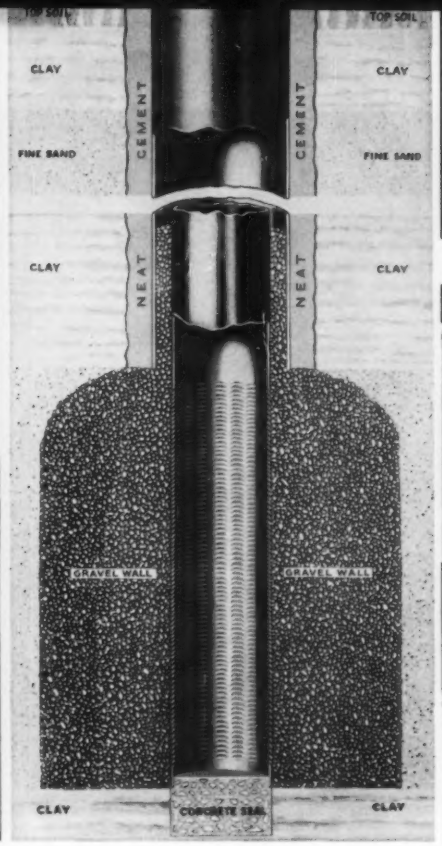
Los Angeles • New York • Houston

*Proprietary name of California Research Corporation





WATER WATER WATER

With A Layne Drilled Well Layne knows where the water-bearing formations are located. They have been drilling wells for over 75 years. This experience comes from searching and researching water aquifers. Knowing *where* to drill is half of the success—knowing *how* is the other half. In drilling a straight well experience counts—and you can count on Layne. Layne specializes in water well drilling. To get a good start for a water supply—you need a good well. You get a good, producing well when you specify a Layne drilled well. *Bulletin No. 100*

With A Layne Gravel Wall Well This technique and resulting arrangement of the new 134 Shutter Screen and gravel (shown here) permits the free flow of water into the well and affords the following advantages: larger shutter screen openings, reduced friction, reduced draw down and pumping head—thereby reducing pumping costs, increased specific capacity and more effective retention of native sands. Cemented wells are installed if indicated, and result in greater purity of supply as well as increased life of the well. *Bulletin No. 900*

With A Layne Vertical Turbine Pump Whatever the pumping requirement, there's a Layne pump to meet any pumping conditions. Layne Vertical Turbine Pumps come in a wide range of sizes and capacities, delivering 30 to 20,000 GPM and requiring from 4 to 42 inch well casings. The complete line of Layne Pumps include: Deep Well Vertical Turbine (oil or water lubricated), Short Coupled Vertical Turbine, Propeller, Mixed Flow, Fire Pumps and Volatile Liquids Pumps, Regular and "In-Line" Submersible. *Bulletins No. 200 (oil) 201 (water)*

LAYNE OFFERS COMPLETE WATER SERVICE: Initial surveys • explorations • recommendations • site selection foundation and soil-sampling • well drilling • well casing and screen • pump design, manufacture and installation construction of water systems • maintenance and service • chemical treatment of water wells • water treatment—all backed by Layne Research. Layne services do not replace, but coordinate with the services of consulting, plant and city engineers.

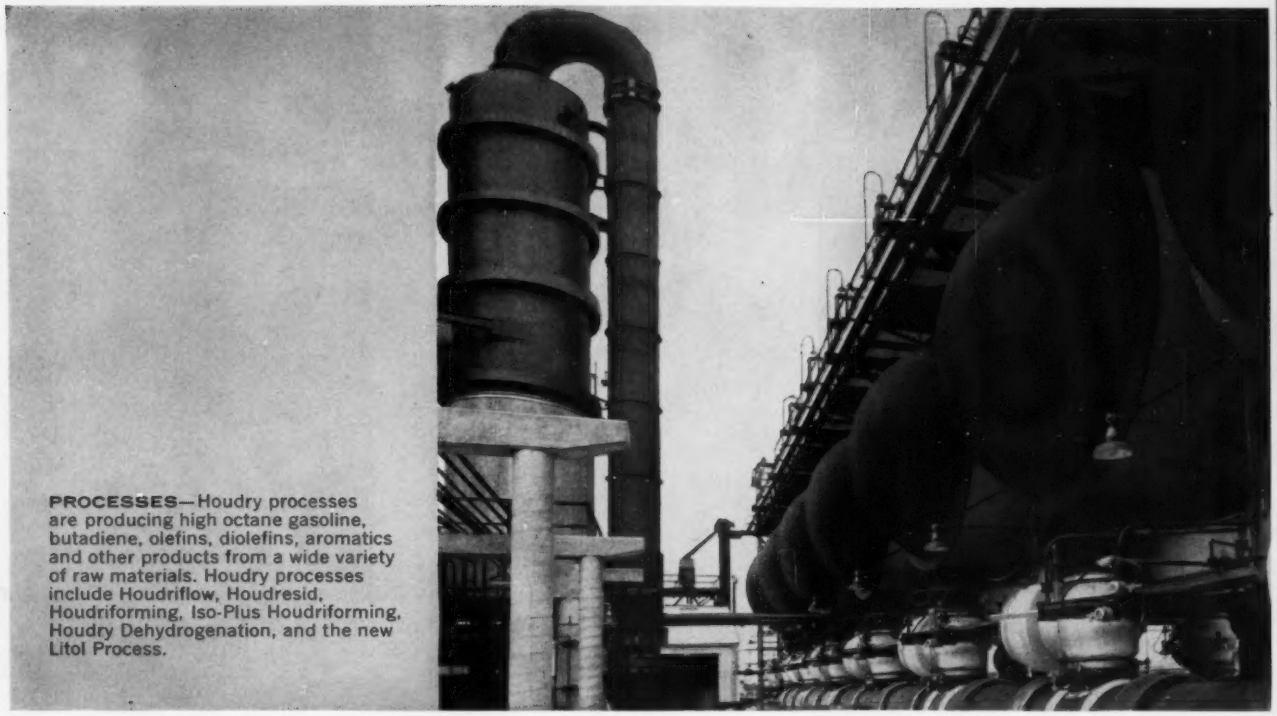
Layne SINCE 1882 — WORLD'S LARGEST WATER DEVELOPERS

LAYNE & BOWLER, INC., MEMPHIS

Offices and Factory—Memphis 8, Tenn.

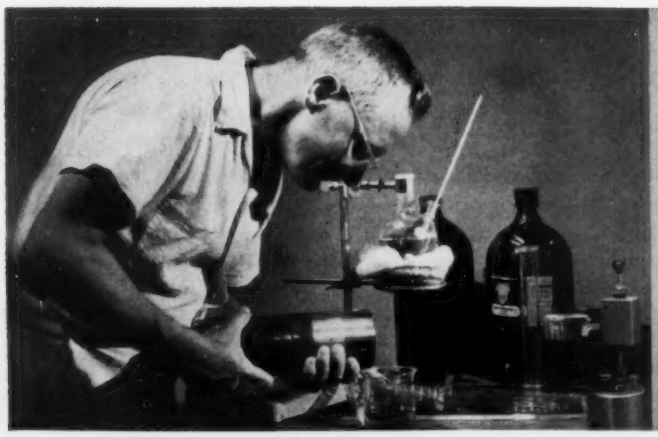
LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD

Sales Representatives in Major Cities

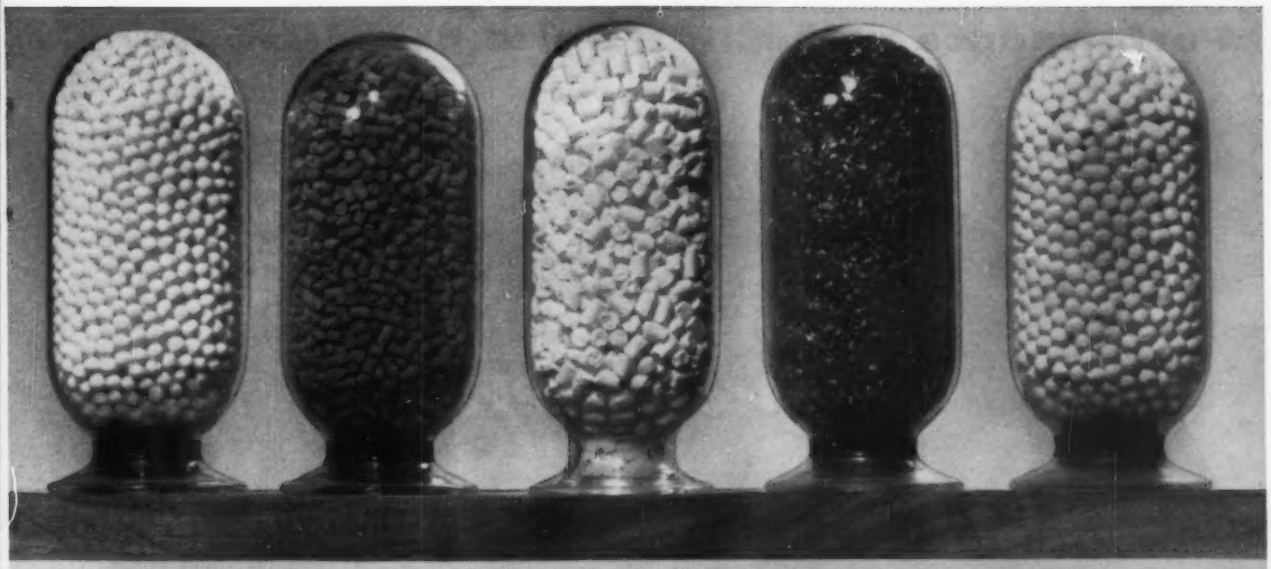


PROCESSES—Houdry processes are producing high octane gasoline, butadiene, olefins, diolefins, aromatics and other products from a wide variety of raw materials. Houdry processes include Houdriflow, Houdresid, Houdriforming, Iso-Plus Houdriforming, Houdry Dehydrogenation, and the new Litol Process.

WHEN THE QUESTION IS CATALYSIS...THE ANSWER IS



CHEMICALS—Developmental work at Houdry has resulted in a number of commercially promising chemicals. They can be generally described as nitrogen containing organic types. More complete descriptions of their properties, typical uses, and possibilities may be obtained on request.



CATALYSTS—Houdry manufactures and supplies a wide range of catalysts for petroleum, petro-chemical and chemical processes. Custom catalysts are also manufactured to order.

HOUDRY

PROCESS CORPORATION

1528 Walnut Street, Philadelphia 2, Pa.

Houdry processes . . . catalysts . . . chemicals . . . services . . . are based on more than 30 years of experience in catalysis. For processors, this extensive experience in different-but-related areas of catalytic processing means unique benefits.

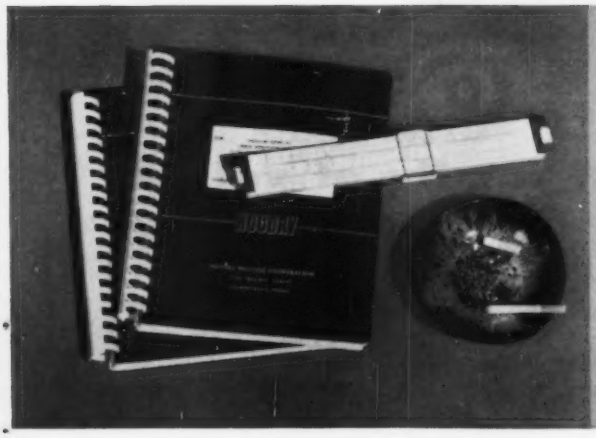
For instance, the catalyst buyer finds—often to his advantage—he is dealing not only with a catalyst manufacturer, but a company fully able to evaluate his process and help him utilize the catalyst more fully than might be possible otherwise.

Likewise, the processor who needs plant-operating assistance finds not only this, but wide experience in engineering and process design, as well.

Houdry process designs are improved by knowledge of catalyst behavior. Services are perfected by experience in continuing research on both processes and catalysts, and so it goes.

Thus the *total* of Houdry's broad experience adds value to specific Houdry products and services.

Today, as ever, here is proof, that Houdry means Progress . . . through Catalysis.



SERVICES—The wealth of experience Houdry has gained in petroleum and chemical processing is available to industry through Houdry services. These include Economic Consultation, Engineering, Research, and Technical Assistance—covering the entire range of catalytic processing.

For more data on advertised products, use Readers' Service Cards, last page.

Performance makes the world of difference

POWELL Lubricated Plug VALVES

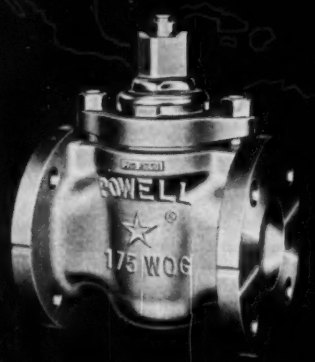


Fig. 2201—Flanged End, semi-steel Lubricated Plug Valve for 175 W.O.G. Single gland type. Wrench operated.

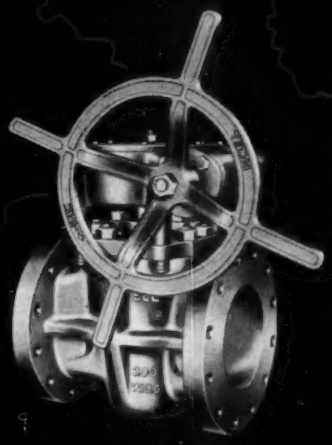


Fig. 2207G—Flanged End, semi-steel Lubricated Plug Valve for 200 W.O.G. Bolted Gland type. Worm gear operated.

Fig. 3058—Screwed End, carbon steel Lubricated Plug Valve, ASA 300 pound. Screwed gland type, wrench operated.

Powell . . . world's largest family of valves

Powell Lubricated Plug Valves—a triumph of valve design and engineering—are preferred to control the flow of fluids in petroleum refineries, petro-chemical plants and oil storage facilities all over the world.

Note these Powell features: simple design (only three basic parts—body, bonnet, plug); fast opening and closing; straight streamline flow through when fully open; tapered plug for positive seating; carefully machined surfaces of plug and body are unexposed to and protected against the action of the fluid being handled when valve is open.

These valves are available in sizes from ½″ through 16″; semi-steel, carbon steel, and, on special order, in other alloys. Consult your nearest Powell valve distributor, or write to us for the facts and illustrated literature.

THE WM. POWELL COMPANY • DEPENDABLE VALVES SINCE 1846 • CINCINNATI 22, OHIO

The warning that comes too late!

WHEN THIS HAPPENS, it's already too late. Lubricant has leaked out, and dirt or grit have probably damaged your bearings and shaft.

You can avoid sealing problems by using Johns-Manville Clipper Seals because you can count on them to outlast time between regular overhauls. They seal efficiently . . . give better protection. That's why Clipper Seals are selected as original equipment by many automotive, marine and aviation manufacturers.

JOHNS-MANVILLE PRODUCES a wide range of sizes and lip designs—including Split Clipper Seals for quick, temporary replacement – in compounds that will resist every heat, speed or corrosive condition. It is smart maintenance practice to use Clipper Seals, and to keep on hand a small replacement stock of the sizes and designs you need regularly.

Let your J-M Distributor help you select the Clipper Seals that are compounded to meet your exact sealing requirements. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE
CLIPPER SEALS

JOHNS-MANVILLE JM PRODUCTS

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Refinery

Maintenance Made Simple

Here are the quality leaders, the names in refining, natural gasoline and petrochem plant equipment synonymous with performance.

When you specify pipe, valves or welding fittings made by these manufacturers, you know you are getting quality. You know that longer service life and less down time result when quality equipment is installed. We are proud to offer you these quality leaders. We know that the research and development invested in these products mean more satisfied customers for J&L.

You can have up-to-date literature on any of these products by calling your local J&L man.

Specify quality.... and save at J&L.

Jones & Laughlin

SUPPLY DIVISION – Tulsa

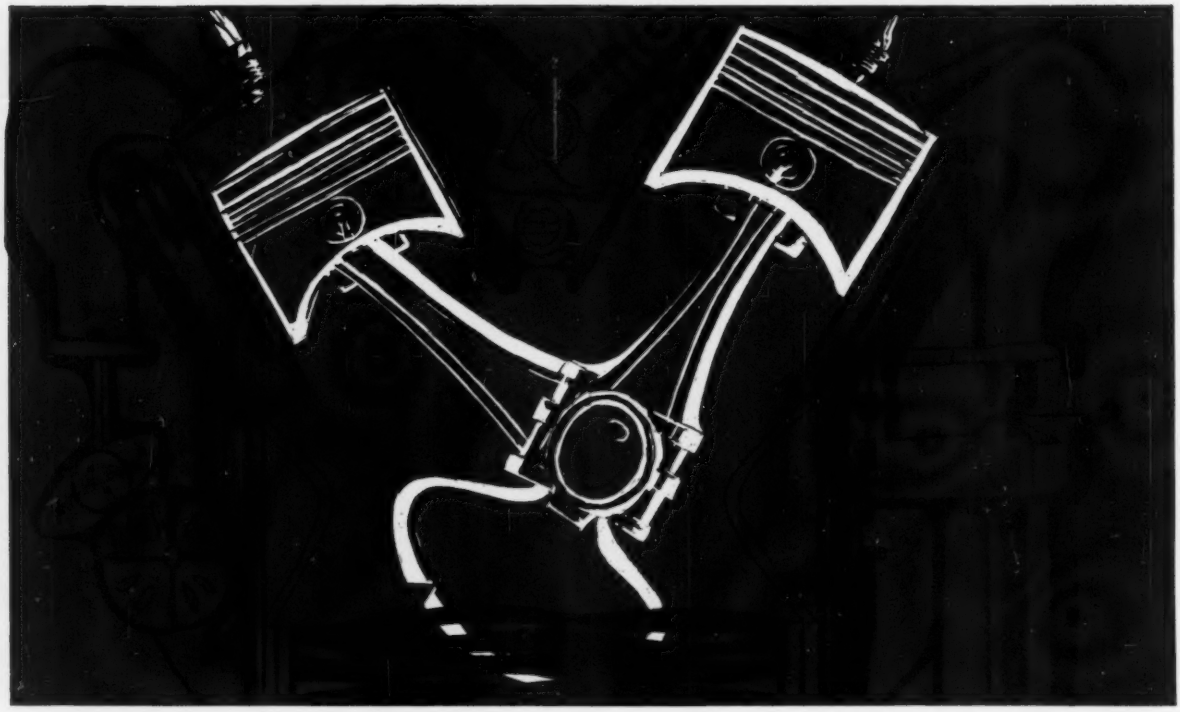
If it's sold by J&L....
It's the best available

108

now...from fmc

a new higher assay...

96+% BaO



for still better barium-based additives!

As leading producers of barium chemicals for the lube oil industry, we've steadily provided more economical barium values and tremendously expanded output to meet growing demand.

Now . . . by an exclusive process just developed . . . we're producing a new, high-quality oxide that consistently assays *above* 96%.

Additive makers and other users can now have a barium unsurpassed in active material content . . . and in a more highly reactive form than has heretofore been possible. Samples and specifications on request.

fmc
FOOD MACHINERY AND CHEMICAL CORPORATION ®

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION
Mineral Products Division
General Sales Offices:
161 E. 42nd STREET, NEW YORK 17

FOOD MACHINERY AND CHEMICAL CORPORATION

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"FRANKLY HOPWOOD,

DON'T YOU THINK IT WOULD BE MUCH MORE PRACTICAL IF WE SENT FOR **BRIDGEPORT'S** FREE NEW BOOK— 'SOLVING CORROSION PROBLEMS IN INDUSTRY'!"

If you convey anything through condensers or heat exchangers, this 20-page Bridgeport book is must reading. It tells how to lick problems involving two corrosive media...by using bi-metal Duplex Tubes ...each metal surface designed to resist corrosion from the media to which it is exposed.

Each industry has its own corrosion problems, and this fact-packed book illustrates ways to solve many of them. For your personal copy, just write, on your company letterhead, to the Bridgeport Brass Company, Bridgeport 2, Connecticut. Please address Dept. 5303.

Bridgeport Brass Co.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut • Sales Offices in Principal Cities

Specialists in Metals from Aluminum to Zirconium

For more data on advertised products, use Readers' Service Cards, last page.

See why ALCOA ALUMINUM makes a good design habit

Requirement: metal pipe and tube to insure corrosion-free fluid handling at low initial cost and minimum upkeep

Key to good design: specify low-cost, trouble-free tubular products of Alcoa Aluminum

The overpowering volume of pipe and tubing needed in the process industries makes it one of the biggest single material investments in most plants. Historically, the repair, maintenance and replacement of piping systems has been too, one of the biggest causes of an alarming increase in maintenance costs. Both factors make vital a clear understanding of the rather remarkable advantages of aluminum pipe and tube.

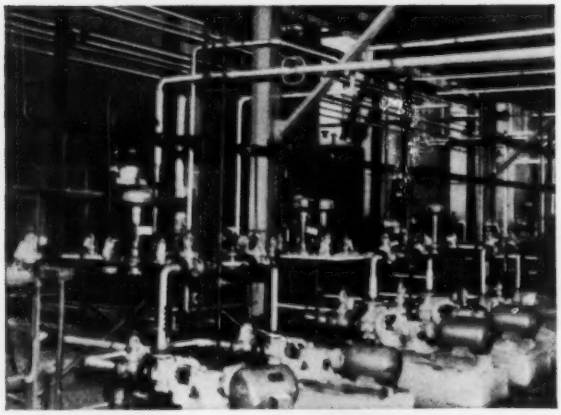
First of all, from a cost standpoint, aluminum is very frequently the lowest cost material suitable for a wide variety of applications in moving fluids through a plant. Consider, for example, the fact that the initial cost of aluminum may often average as much as 50 per cent less than that of admiralty for identical applications. Even greater savings apply when other metals such as stainless or mild steel are compared with aluminum.

Beyond these initial cost savings, aluminum provides significant maintenance benefits. For instance, no other commonly used metal offers aluminum's great resistance to corrosion. And the corrosion resistance for specific alloys exposed to particular environments can be determined from a substantial body of factual service data accumulated by ALCOA over the past 40-odd years.

It is hardly surprising that aluminum, in a variety of tubular forms, is gaining the confidence of more and more designers and builders in the process industries . . . as suggested by the aluminum applications described on these pages. ALCOA's engineers are anxious and willing to share their factual knowledge of aluminum which inspires this confidence. They are doing so through a series of engineering conferences being held this year in major cities around the country. Your local ALCOA sales office will be happy to furnish details.

You may also wish to avail yourself of the body of ALCOA literature which describes in technical detail the known performance characteristics of aluminum in a variety of process industries applications. Simply fill in and mail the coupon opposite.

World wide sales through ALCOA INTERNATIONAL, INC., 230 Park Avenue, New York 17, N.Y.

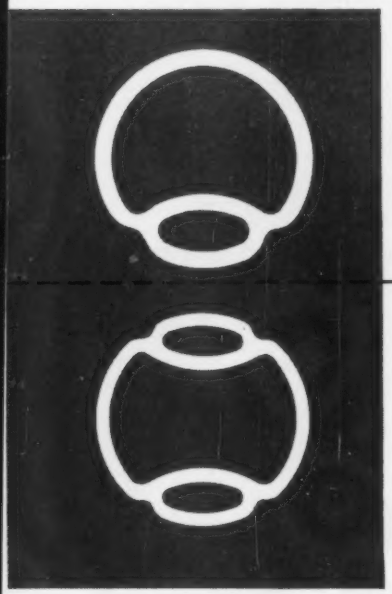


Process piping of Alcoa Aluminum is shown here in a system designed to handle liquid sugar. The natural corrosion resistance of aluminum prevents contamination of the syrup, insures long service life and prevents excessive maintenance. Its scavenging action reduces undesired heavy metal contamination, thereby improving the end product. And aluminum's low friction factor permits fast flow without excessive pumping costs.

This aluminum pipeline is shown being welded and laid in Lake Maracaibo, Venezuela. Aluminum—without special coatings—has proved highly suitable for this operation because it resists so well the corrosive attack of the brackish waters in the lake. Since no coating is required, the low initial cost of the aluminum has proved a significant benefit. The light weight of the aluminum pipe speeded laying operations, and it has no vulnerable coating which would require babying the pipe.

Alcoa Aluminum jacketing keeps the thermal insulation on these large diameter steam lines fully effective. The light, bright aluminum jacketing shields over 5½ miles of piping and insulation from rain, snow, dirt and ice while providing effective protection against a highly corrosive industrial-marine atmosphere.

New UNISTRENGTH pipe by Alcoa now makes it possible to design low-cost welded aluminum lines with uniform bending, bursting and tensile strength throughout their length. The secret is a reduction in wall thickness everywhere but at the ends where it is needed to overcome the local reduction in strength caused by the heat of welding. The result is aluminum piping which weighs up to 40% less but provides equivalent design strength.

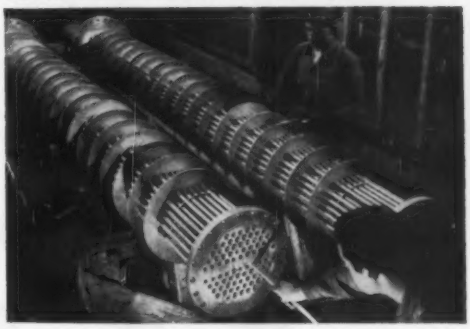


Alcoa UNITRACE is the light, strong, corrosion resistant pipe which provides steam and product passages in a single extruded unit. It has proved an excellent way to cut cost and improve the efficiency of steam traced lines—by eliminating costly external steam jackets or inefficient tracer tubes. Now a new product,

Alcoa DUOTRACE makes possible the same important benefits in steam traced systems where recirculation is desirable. As shown, DUOTRACE provides two trace passages plus the product passage in one extruded unit. Flange and Trace Cap fittings compatible with conventional piping are available for both UNITRACE and DUOTRACE.

Design Note: Consider UNITRACE and DUOTRACE as low-cost successors to both heat exchangers and preheaters.

Alcoa Aluminum heat exchanger tubing is frequently the lowest cost material with suitable corrosion resistance for a variety of heat transfer applications. Moreover, aluminum frequently displays significant extra benefits—as in this pair of aluminum oil-to-oil exchanger bundles for preheating vegetable oils. Here, the aluminum alloys have no catalytic effect on the oxidation of the vegetable oil.



ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

For exciting drama watch "ALCOA PRESENTS" every Tuesday, ABC-TV, and "ALCOA THEATRE" alternate Mondays, NBC-TV

Aluminum Company of America, 874-E Alcoa Building, Pittsburgh 19, Pa.

Please send me the following literature covering Alcoa Aluminum for tubular products and other uses in the process industries:

- ☐ 10197 Aluminum Pipe and Fittings
- ☐ 34-10418 Alcoa Unitrace: Combines Piping and Tracing in One Unit
- ☐ 10270 Alcoa Utilitube
- ☐ 10460 Process Industries Applications of Alcoa Aluminum
- ☐ 20849 Resistance of Aluminum Alloys to Weathering and Resistance of Aluminum Alloys to Chemically Contaminated Atmospheres
- ☐ 20265 Have You Tried Aluminum in Your Refinery?
- ☐ 20437 Aluminum Alloy Heat Exchangers in the Process Industries
- ☐ 20272 Aluminum Alloys for Handling High Purity Water
- ☐ 21090 Resistance of Aluminum Alloys to Fresh Waters
- ☐ 10130 Forming Alcoa Aluminum
- ☐ 19416 Brazing Alcoa Aluminum
- ☐ 10415 Welding Alcoa Aluminum
- ☐ 19051 Alcoa Aluminum Handbook

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the remarkable new pipe insulation that's really TOUGH!

ZEBRA

You don't have to handle Zebra with kid gloves. This multi-layer sectional-type thermal insulation has real body . . . doesn't break easily. In fact, its deflection at breaking point is 2 to 4 times that of ordinary insulation.

A low, medium, and high-*temperature* pipe insulation, Zebra is made in half sections in all pipe sizes to facilitate handling and reduce the number of joints. This, plus its light weight, speeds application and keeps installation cost *low*. Zebra is easy to cut and fabricate. And it's reusable . . . can be dismantled and re-applied.

What's more, Zebra won't cause skin irritation or cuts. It has a smooth surface . . . no ragged ends. And it's practically dust free.

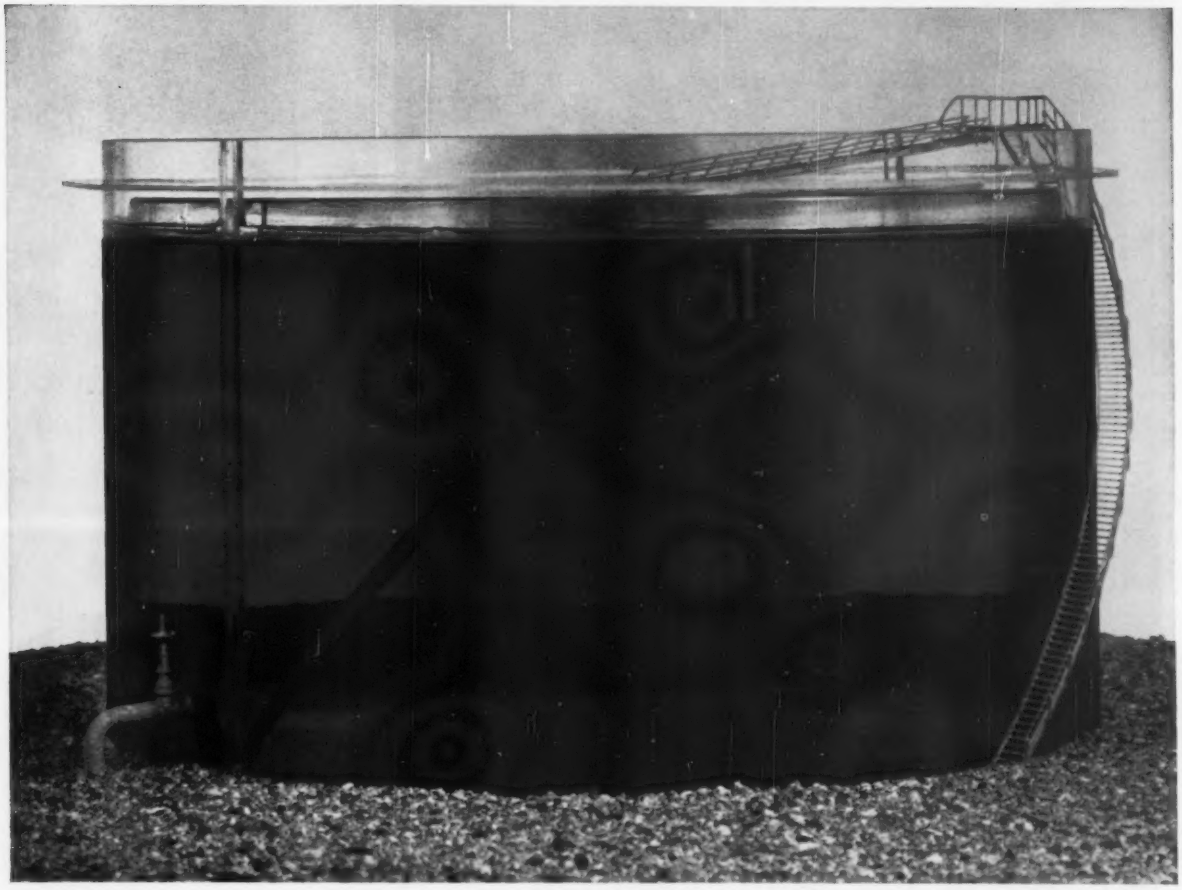
• for temperatures of 200° F to 1200° F • made of calcium silicate-asbestos fibre bonded felts • withstands shock and heat without warping or abrading • meets requirements for density, conductivity, modulus of rupture • available in wide range of sizes and thicknesses • tested by an independent testing laboratory

Write today for more information on "K&M" Zebra—the remarkable new pipe insulation that's really tough! Keasbey & Mattison Company, Ambler, Pa., Dept. I-250.

K·M
BEST IN ASBESTOS

KEASBEY & MATTISON at Ambler

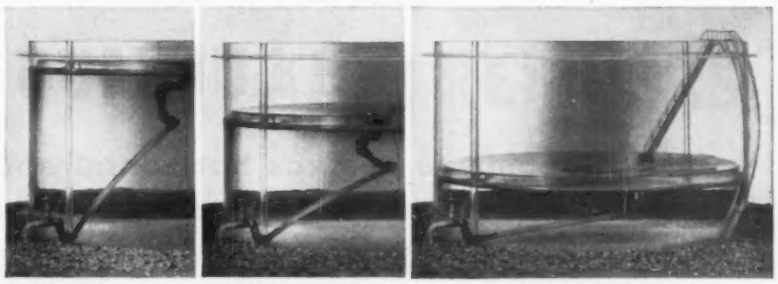
ON FLOATING ROOFS–



Chiksan Swivel Jointed Drain Lines team up strength + flexibility + endurance

The unlimited flexibility of Chiksan swivel joint equipped floating roof drains mean money saved on every tank. First, Chiksan drains cost less than rubber hose —and, you count their useful life in years instead of months. Chiksan swivel joints and lines easily withstand tank pressures —never kink to cause drain stoppage. Both lines and joints are available in many types of metals to meet specific liquid storage requirements.

Plan now to include Chiksan drain lines in all new tank installations and in present lines that need replacement. For details, contact Chiksan or your nearby Chiksan field representative.



FULL TANK. Drain line flexes readily. Easily withstands tank pressures.

TWO THIRDS FULL. All metal line moves freely with the floating roof without danger of kinking.

TWO THIRDS EMPTY. Line folds compactly. Provides long years of trouble-free service.

CHIKSAN fmc

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

#60-49

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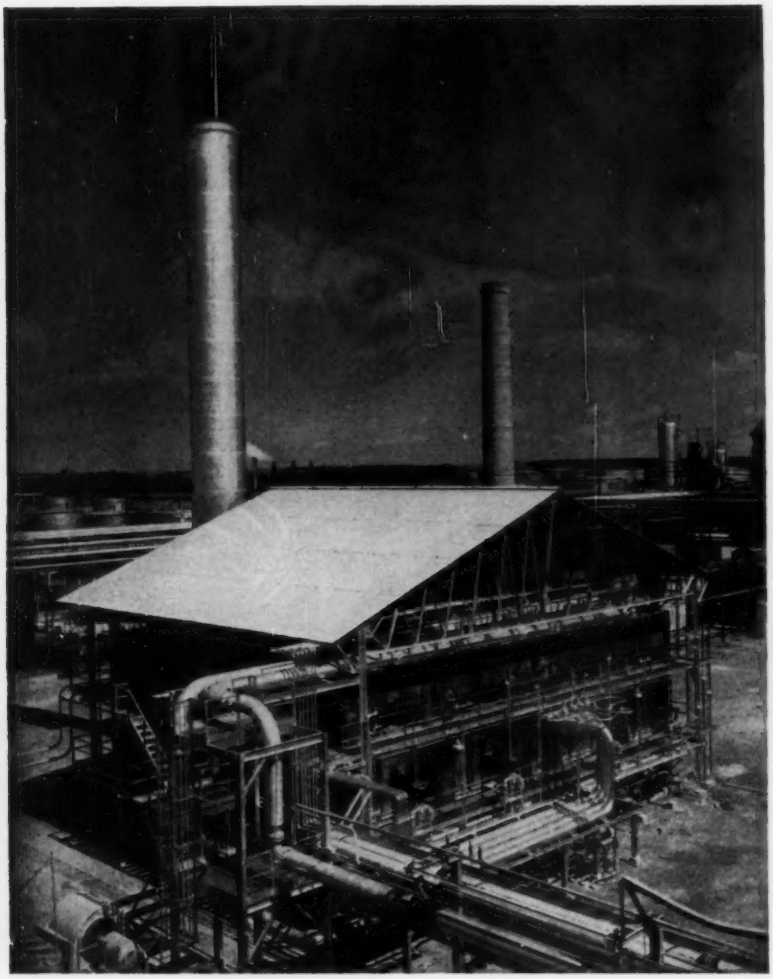
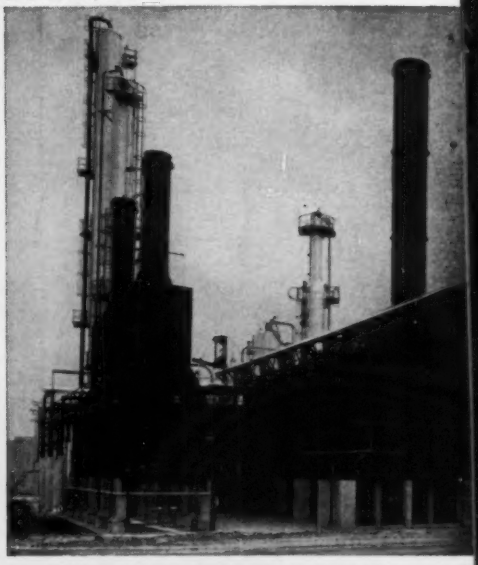
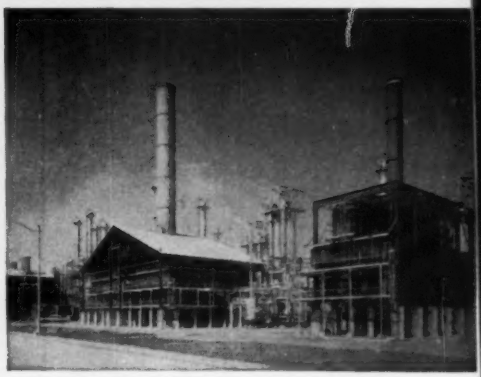


Portable crude heater for Magnolia Petroleum Company, Beaumont, Texas.

Ultraformer heater for American Oil Co. at El Dorado, Arkansas.





Platformer and desulphurizer heaters for Shell Oil Co. at Deer Park, Houston, Texas.

HIGHER EFFICIENCY, LUMMUS OIL HEATERS

Lummus designs horizontal and vertical-tube oil heaters to any size, for any process—anywhere in the world

Major refiners confidently turn to Lummus on their important and difficult oil heater jobs.

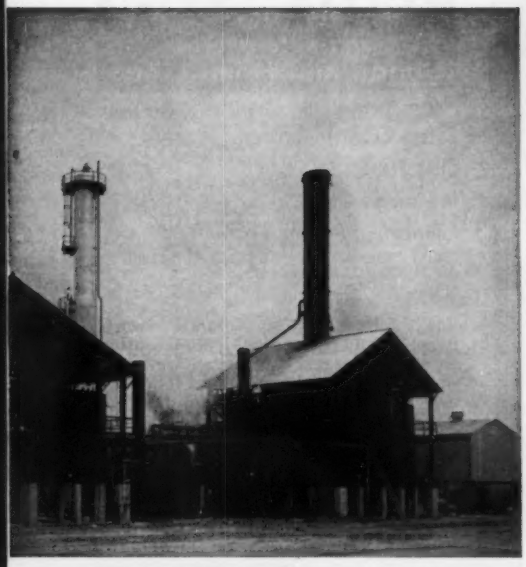
In the last 25 years, the combined capacity of all Lummus oil heaters built has exceeded that of any other company in the world. The reasons: greater durability, more efficient operation, an absolute minimum of days lost to downtime.

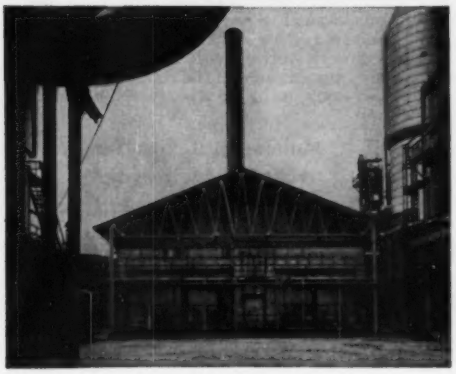
Major refiners maintain large engineering and economics staffs who can evaluate the performance of important heating equipment. They buy more Lummus oil heaters because they *know* through statistical comparison that Lummus gives them *more heater per dollar.*

Lummus offers over a quarter of a century of oil heater experience for petroleum refineries, chemical and petrochemical plants. The highly trained engineering staff of the Oil Heater Division is ready in the Lummus New York office to give each job the full benefit of its accumulated know-how in this field.

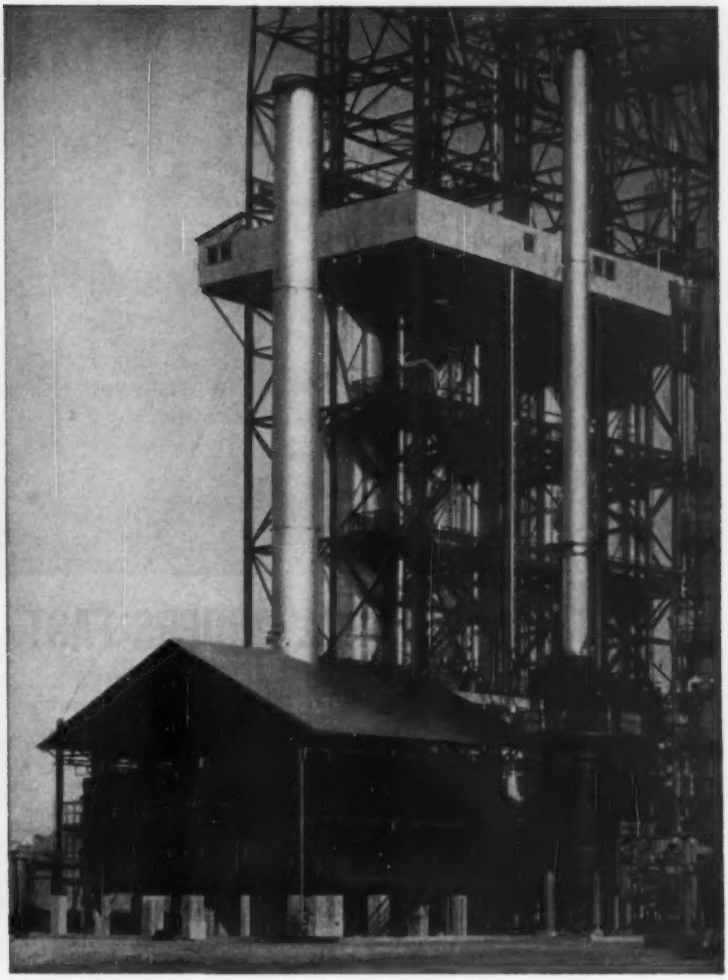
Lummus oil heaters, of both special and standard design, range from 100,000 to 300,000,000 Btu per hour. As illustrated above, neither size, type nor location of the unit presents a problem to Lummus. Because Lummus offers *every* type of oil heater, you can be sure that we will recommend the *right*

For more data on advertised products, use Readers' Service Cards, last page.





Crude heater for Socony Mobil at Paulsboro, N. J.



Delayed coker heater for the American Oil Co. at Yorktown, Virginia.

MINIMUM DOWNTIME MAKE PREFERRED AMONG MAJOR REFINERS

unit for your needs. Complete Lummus facilities are available world-wide through any of the five international Lummus companies. Equipment is designed in New York, procurement is made through the nearest Lummus international office, and the cost of the job is payable in the currency of the country in which the procurement is handled!

Consult with Lummus on your next oil heater – large or small.

LUMMUS

THE LUMMUS COMPANY, OIL HEATER DIVISION
385 MADISON AVENUE, NEW YORK 17, N. Y.

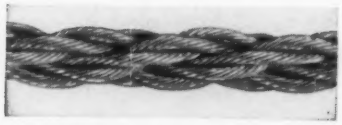
For more data on advertised products, use Readers' Service Cards, last page.

DISTRIBUTORS FILL ORDERS FAST
for Factory-Fitted Tuffy Slings

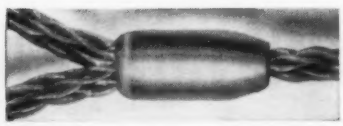
When time counts, you can count on your Tuffy distributor. Tuffy slings are factory-fitted, factory-packaged and easy to order. They are delivered to you as a complete package — ready to go to work right now.

No complicated specifications in ordering. Tuffys are "tailored" to special uses. Select the sling for the type load you're handling. Just say Tuffy, specify type (U-1, U-2, etc.) and specify diameter and length of fabric wanted.

Why Tuffy Gives You More Service Life Per Dollar



Tuffy's patented 9-part machine-braided fabric combines extra strength and toughness with extra flexibility. Kinks rarely occur. If one does, it's easily smoothed out, leaving sling undamaged.



Tuffy's pressed-on metal ferrule is applied under hydraulic pressure so great that the eye splice has the full strength of the machine-braided fabric. Another Tuffy extra at no extra cost.

Get in Touch with Your Tuffy Distributor

He's set up to serve you fast on every sling need, including the new Union hand-braided slings. And he's backed by his nearby Union Wire Rope depot to assure no time lost in filling orders of unusual nature or quantity.

Tuffy® Tips
—on safe use of
Slings and Hoist Lines

Safety Council Cites Factors in Lifting Injuries

The National Safety Council reports nearly a fourth of all compensation cases are the result of unsafe handling methods or conditions. The following are listed as factors contributing to handling injuries:

"(a) Handling loads that are too heavy; (b) lifting or lowering with the back muscles instead of the leg muscles; (c) handling load with an insecure grip and failing to watch where hands are placed; (d) handling without sufficient help or failing to use mechanical equipment; (e) handling before getting a firm footing; (f) lifting or lowering with a jerking, twisting movement of the body, or when the body is in an awkward position."

Maintenance Tips for Hoisting Equipment

(1) Be sure crane and hoist controls are in proper working order. Don't use equipment that hasn't been tested recently.

(2) Inspect hitching equipment before it is used. Re-check after use.

(3) Remove hitching equipment not in use from hooks, hoists and loads. Don't allow it to remain loose.

(4) Store slings systematically when they're not in use. Don't let them lie around helter-skelter. They may be damaged between lifts.

FREE!
New Tuffy Sling Handbook

All about slings from A to Z, including types, dimensions and rated loads. Address **Union Wire Rope Corporation, 2284 Manchester Ave., Kansas City 26, Missouri.** Specialists in high carbon wire, wire rope, braided wire fabric, and stress relieved wire and strand.

3

UNION Wire Rope

Subsidiary of ARMCO STEEL CORPORATION

OTHER SUBSIDIARIES AND DIVISIONS: Armco Division • Sheffield Division • The National Supply Company
Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Southwest Steel Products

Eastman now offers paraffin formulators 7 basic types of polyethylene

New Epolene resins broaden formulation range of paraffin waxes

The wide range of physical properties available in Eastman's series of low-molecular-weight Epolene resins provides formulating flexibility never before possible. With the addition of three new resins (Epolene LVE, HDE and HD), you can now choose from among seven different types to improve your wax formulations or to develop new ones.

Epolene polyethylene improves the properties of paraffin blends in these ways:

- reduces flaking
- increases toughness
- increases abrasion resistance
- improves adhesion
- improves resistance to thermal shock
- increases mileage
- raises blocking temperature
- improves gloss

Each type of Epolene polyethylene contributes, to a greater or lesser degree, to the improvement of each of these properties. Thus, through selective blending, you can formulate waxes of optimum performance for your equipment and service.

New and expanded production facilities at Longview, Texas, assure the immediate availability of all Epolene resins.

Epolene E *oxidized* • In general, the oxidized Epolene resins improve the adhesion of paraffin blends to a greater degree than do the non-oxidized types. Among the oxidized types, Epolene E is superior in this respect, and in its ability to increase the softening point of paraffin blends.

Epolene LVE *oxidized* • When good adhesion and a low cloud point are important, Epolene LVE should be considered as a component in paraffin blends.

Epolene HDE *oxidized* • This is the first high-density, oxidized low-molecular-weight polyethylene available. Epolene HDE is suggested for use in wax blends that must exhibit good adhesion and mileage.

Epolene N *non-oxidized* • Epolene N contributes maximum hardness and high tensile strength to paraffin blends. It also enables coaters to obtain excellent mileage.

Epolene LV *non-oxidized* • Epolene LV is one of the easiest to handle among the low-molecular-weight polyethylene resins, because of its low melt viscosity. Paraffin blends containing Epolene LV also exhibit low viscosities at application temperatures, and relatively low cloud points.

Epolene HD *non-oxidized* • Epolene HD is the hardest of all the low-molecular-weight polyethylene resins, yet is easy to handle due to its low melt viscosity. It produces paraffin blends that have high softening and blocking temperatures.

Epolene C *non-oxidized* • Epolene C, a unique polyethylene resin, has the highest molecular weight and lowest density of all the resins in the Epolene series. Contributing maximum tensile strength in conventional blends, Epolene C is also being used to advantage in coatings in which it is the principal component.

If you are using low-molecular-weight polyethylenes in your wax formulations, or are considering their use, investigate the complete Epolene series. Your Eastman representative will gladly explain the advantages of each of the resins in the series and will show you how to realize the most profitable use of them in your formulations. Write today for more information.

Physical Properties of 2% EPOLENE-Paraffin Blends
(130° AMP Paraffin)

PROPERTY	EPOLENE TYPE						
	E	LVE	HDE	N	LV	HD	C
Density *	0.938	0.939	0.956	0.928	0.925	0.938	0.907
Viscosity, cps.	4.8	5.5	5	5.2	4.3	5.4	5.2
Ring and Ball Softening Point, °F.	145	138	140	140	140	145	139
Penetration Hardness, 0.1mm.	15	11	11.5	15.6	13.9	13.9	13.3
Adhesion, Psi.	13.5	13.5	11	8	8.5	5.5	10.5
Cloud Point, °F.	174	165	183	185	176	190	170
Consumption, G./100 in.²	3.79	4.49	3.29	3.69	3.86	4.71	4.32
Tensile, Psi.	455	435	280	470	465	355	470

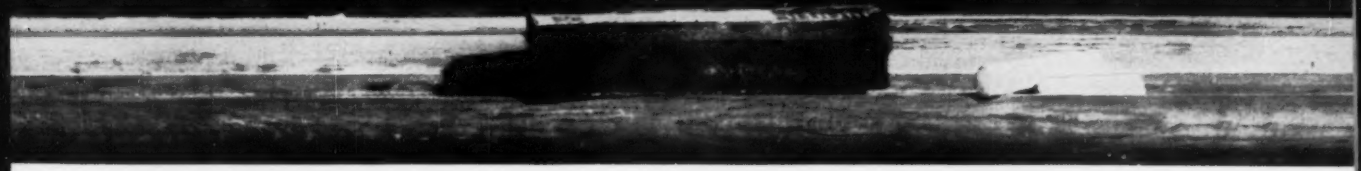
*Density of unblended Epolene

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tennessee; Atlanta; Chicago; Cincinnati; Cleveland; Detroit; Framingham, Massachusetts; Greensboro, North Carolina; Houston; New York; Philadelphia; St. Louis. **West Coast: Wilson Meyer Co.,** San Francisco; Los Angeles; Portland; Salt Lake City; Seattle.

Epolene®

EASTMAN low-molecular-weight polyethylene resins

On most this valve never needs



There are a few valve-killing services where Rockwell-Nordstrom valves *do* fail—after outlasting non-lubricated valves by ten or twenty times. But on *most* services—when properly specified and properly maintained—they last as long as the installation of which they're a part. This is why: Rockwell-Nordstrom valves are *lubricated*. Pressurized lubricant in the Sealdport system does three things. 1) It creates a powerful leak-proof seal that can't be permanently damaged because it *renews itself*. 2) By hydraulically cushioning the plug, lubricant *prevents freezing and jamming*. 3) Lubricant protects every moving part against wearing *friction* and no vital part is exposed to the line. The lubri-

Lubrication makes the

cation largely eliminates the *causes* of valve failure. How much would you save if you had a valve that never needed to be replaced—or that outlasted your present valves by ten or twenty times? Try just *one* Rockwell-Nordstrom Valve on your toughest service. *Rockwell Manufacturing Co., Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Ltd.*

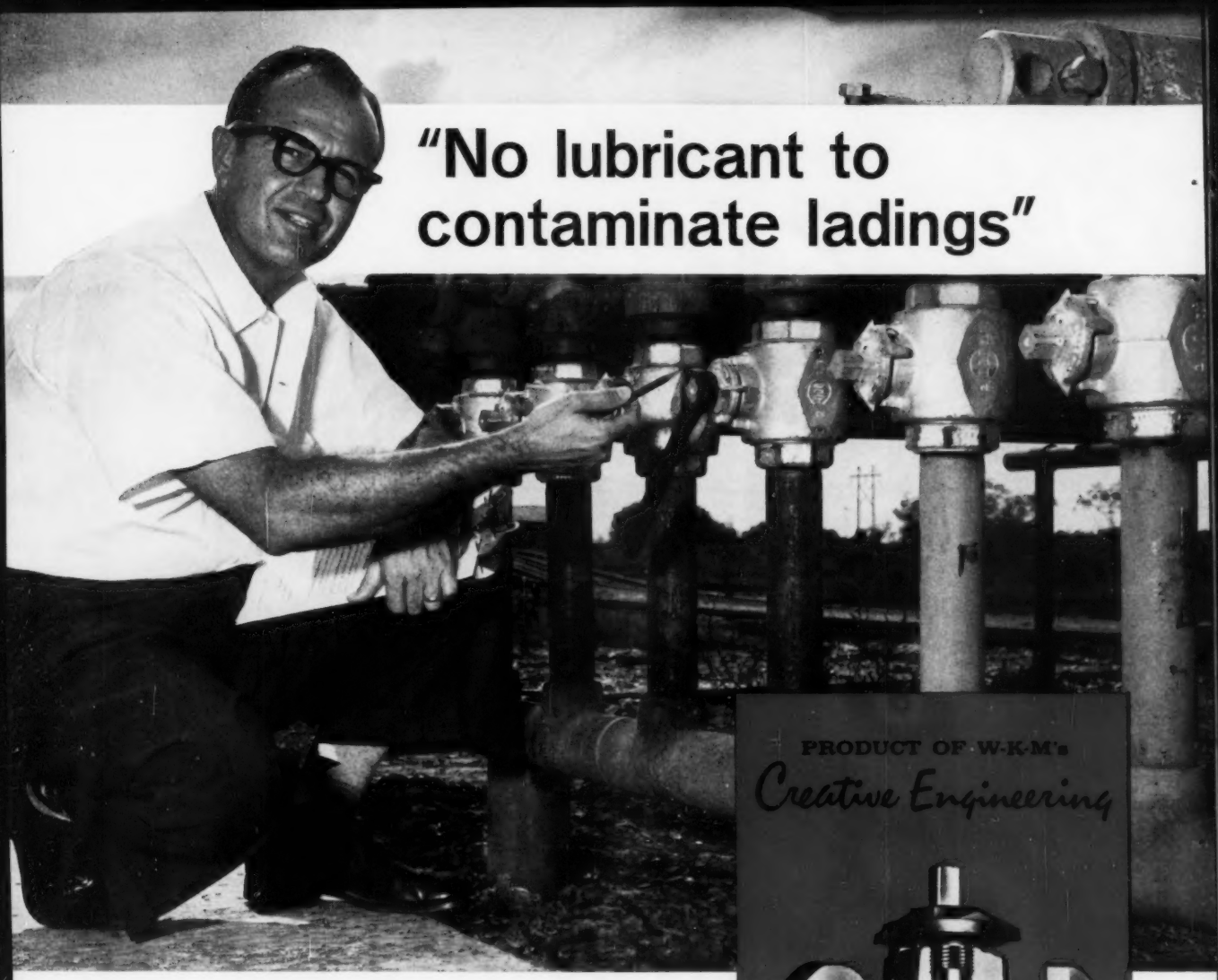
ROCKWELL-Nordstrom VALVES

another fine product by

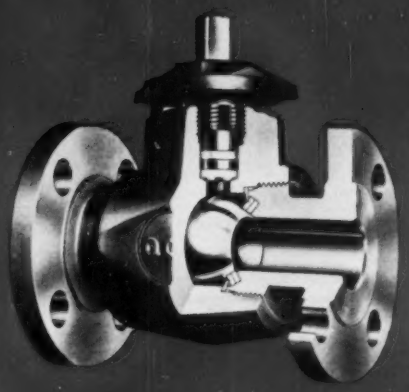
ROCKWELL

difference . . . . . .

"No lubricant to contaminate ladings"



PRODUCT OF W-K-M's *Creative Engineering*



acf® non-lubricated Ball Valves

ACF Ball Valves are specially designed for ladings that require absolute purity. There is no lubricant, no possibility of contamination. The chrome-plated ball is suspended between Teflon seats under compression for leakproof sealing.

A quick quarter-turn operates this rugged valve. Specify it. You'll get efficient, economical performance. *Available at leading supply stores everywhere.*

Service-proved for 5½ years with such ladings as: gasoline • alkalis • liquefied petroleum gases • acetone • synthetic fuels • paint solvents • toluol • alcohol.

WRITE FOR CATALOG 1000

W-K-M

DIVISION OF acf INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS

ACF non-lubricated Ball Valves feature full bore conduits, Teflon stem gaskets and seats that are sealed from the lading flow.

Working Pressures: In carbon steel with ASA ratings of 150 and 300, and a few sizes in ASA 600; in semi-steel with 200 and 400 pound ratings.

Sizes: ½" through 6".

5911-R2

REFRACTORY & INSULATING CONCRETES

(REFRACTORY CASTABLES)

For the

OIL INDUSTRY

made with CIMENT FONDU — Reg'd Trade Mark — ALUMINOUS CEMENT

can be "gunned" or cast-in-place, and depending on the aggregates used can have any fired density between 30-120 lbs. per cu. ft.

Montreal refinery. Regenerator towers gunited

Kwinana refinery. Towers gunited

Aden refinery. Reactor and chimney stack linings

and NOW! SECAR 250

Secar 250 refractory castables have all the advantages of Fondu castables PLUS high purity and high refractoriness.

SECAR 250

a super-purity white calcium-aluminate cement with IRON COMPOUNDS AND SILICA LESS THAN 1% suitable for IRON-FREE REACTOR LININGS, SUPER-DUTY CASTABLES, and the HIGHER TEMPERATURE APPLICATIONS.

WRITE FOR LITERATURE ON:

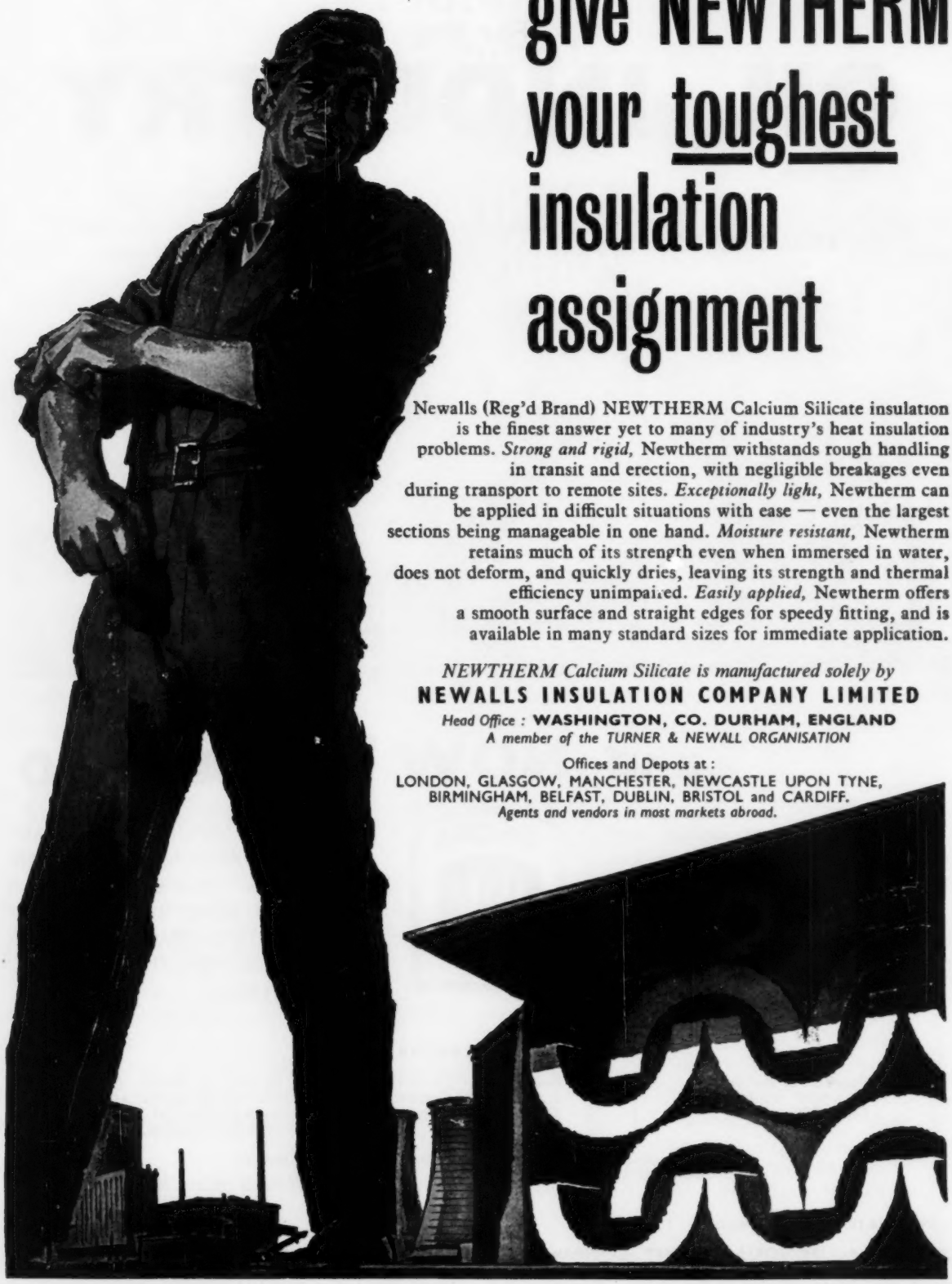
1. Super Duty Refractory Concretes made with Secar 250.
2. Refractory Concrete made with Ciment Fondu.
3. List of British Castable Manufacturers and Special Aggregate Suppliers.
4. Heat Insulation with Insulating Concrete.
5. High-Alumina cement in oil-refineries.

AVAILABLE THROUGHOUT THE WORLD

LAFARGE ALUMINOUS CEMENT COMPANY LIMITED, 73 BROOK STREET, LONDON, ENGLAND

Ciment Fondu Lafarge Corporation, 122 East 42nd St. New York 17, N. Y. Ciment Fondu Lafarge (Canada) Ltd., 1405 Peel St. Montreal, P.Q.

For more data on advertised products, use Readers' Service Cards, last page.



give NEWTHERM your toughest insulation assignment

Newalls (Reg'd Brand) NEWTHERM Calcium Silicate insulation is the finest answer yet to many of industry's heat insulation problems. *Strong and rigid,* Newtherm withstands rough handling in transit and erection, with negligible breakages even during transport to remote sites. *Exceptionally light,* Newtherm can be applied in difficult situations with ease — even the largest sections being manageable in one hand. *Moisture resistant,* Newtherm retains much of its strength even when immersed in water, does not deform, and quickly dries, leaving its strength and thermal efficiency unimpaired. *Easily applied,* Newtherm offers a smooth surface and straight edges for speedy fitting, and is available in many standard sizes for immediate application.

NEWTHERM Calcium Silicate is manufactured solely by

NEWALLS INSULATION COMPANY LIMITED

Head Office : **WASHINGTON, CO. DURHAM, ENGLAND**

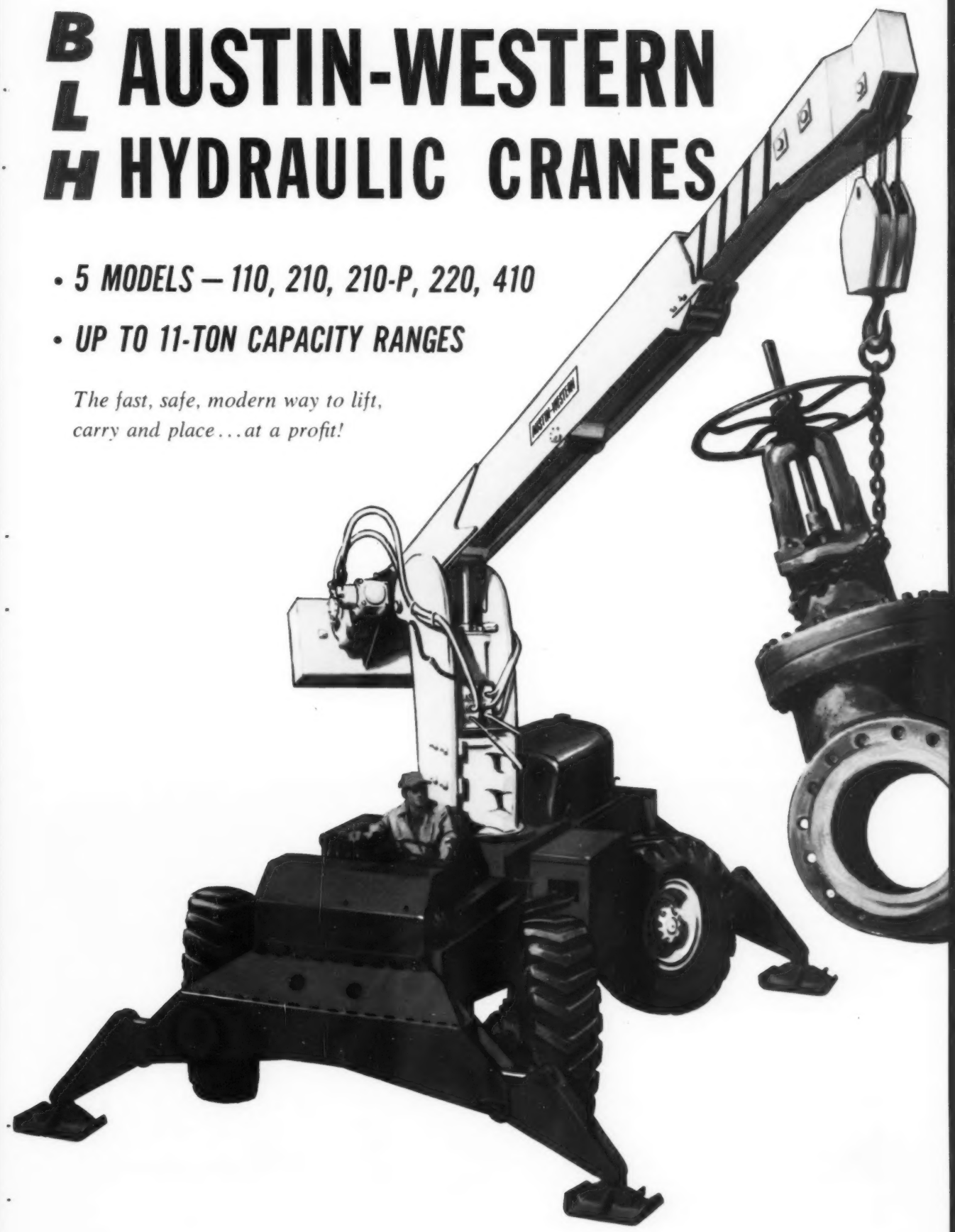
A member of the TURNER & NEWALL ORGANISATION

Offices and Depots at :
LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL and CARDIFF.
Agents and vendors in most markets abroad.

BLH AUSTIN-WESTERN HYDRAULIC CRANES

- *5 MODELS — 110, 210, 210-P, 220, 410*
- *UP TO 11-TON CAPACITY RANGES*

The fast, safe, modern way to lift, carry and place . . . at a profit!



Austin-Western's telescoping delivers unequaled precision,

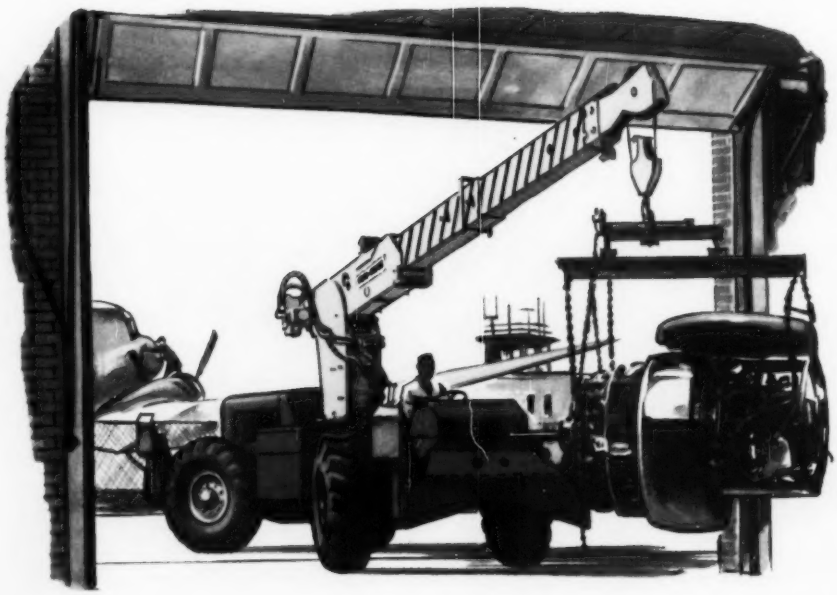
MODEL 110

5-ton range — The 110 is the mighty midget of the A-W line—but what a midget! It'll outlift all other 3-wheel cranes over-the-side! It's industry's answer to fork truck limitations. The 110 has an 18 ft. 7 in. boom reach; 220° boom swing. Low 8 ft. 10 in. overhead clearance. Operates with ease in close quarters; handles loads in 5-ton range.

Features dual front driving wheels; dual tire rear trunnion power steer — road speeds from 2 to 18 mph. Torque converter and full hydraulic reversing mechanism standard. The unit can be tailored to your particular job needs with various combinations of features and equipment.

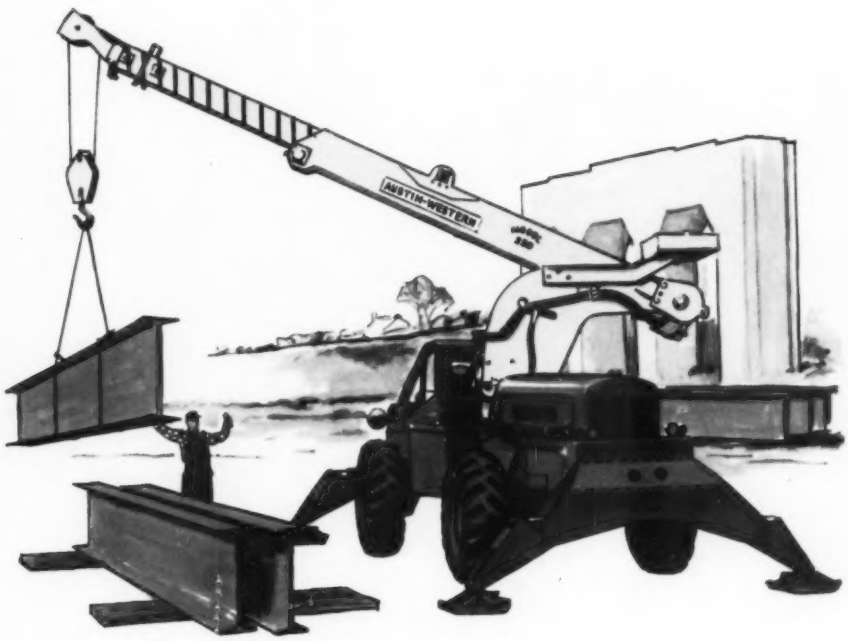
MODEL 210

7-ton range—This basic model of the hydraulic crane line is rubber mounted, self-propelled; capable of road speeds up to 35mph. A real workhorse for an astounding variety of lift, carry and place assignments. 18-foot telescoping boom rotates in continuous full circle, maximum 35-foot boom reach optional. All-wheel steering gives unlimited maneuverability in tightest spots; all-wheel drive means plenty of traction for loaded boom travel on any surface. Low overhead clearance. Operation is fully hydraulic, including outriggers.



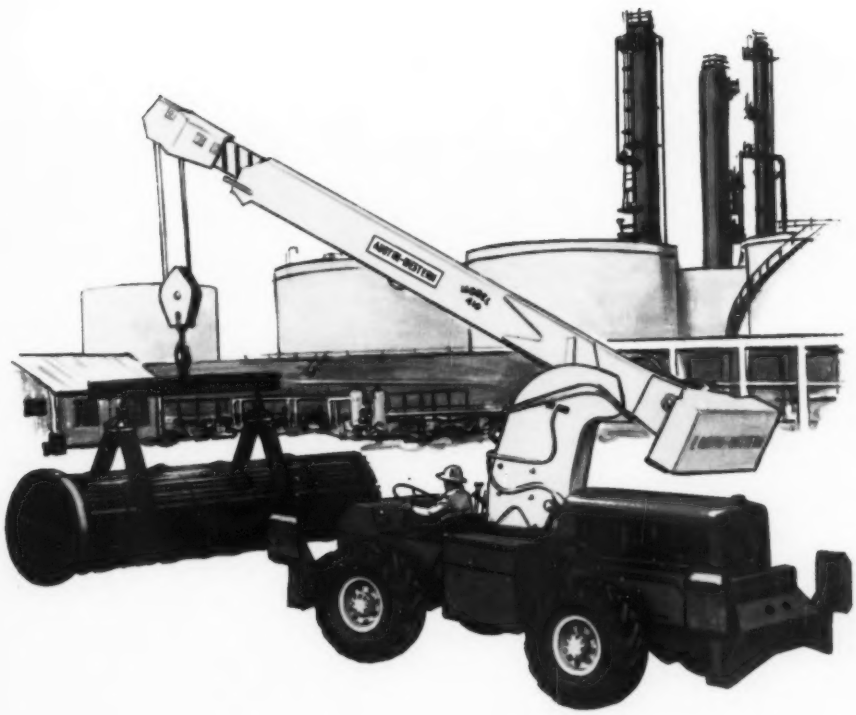
live hydraulic boom safety, flexibility

- ***Extends and retracts***
- ***Raises and lowers***
- ***Reaches up and in***
- ***Reaches out and over***
- ***Full hydraulic control***
- ***Two or more movements with full boom load***
- ***Continuous full circle rotation on most models***



MODEL 220

8-ton range—The Model 220 is a modified version of the basic Model 210. Its counterweighted boom as well as heavier structural design give it added lifting capacity into the 8-ton range. Like the 210, it features an 18-ft. telescoping boom, with maximum 35-ft. boom reach optional; continuous full circle swing; all-wheel drive and all-wheel steering. Full hydraulic controls mean tops in precision, safety, ease of operation.



MODEL 410

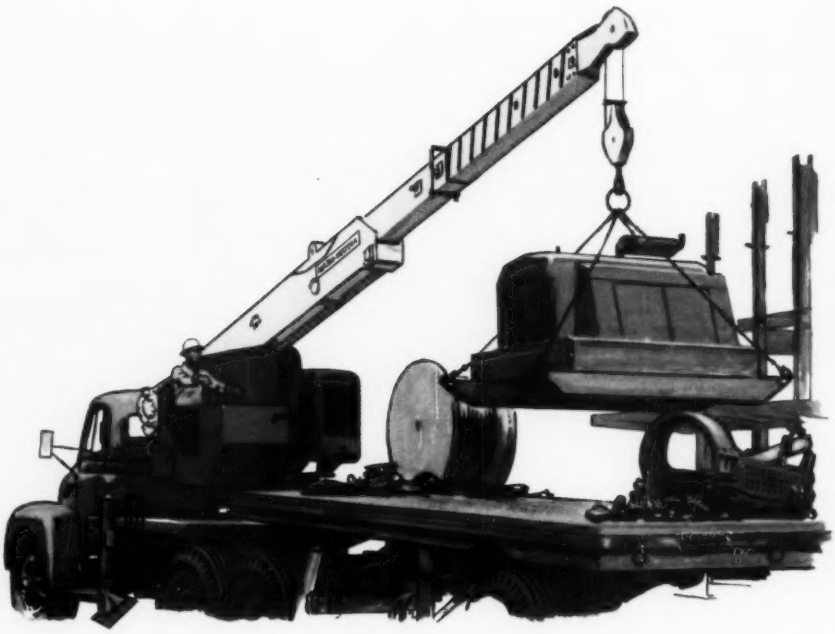
11-ton range — This big brute, the Model 410, is the heavy-duty unit in the A-W crane line. Like the 210 and 220, it is self-propelled; 25-ft. telescoping boom rotates in continuous full circle with maximum 48-ft. boom reach optional; raises to a 60° angle from horizontal.

Gas or diesel power; all-wheel drive and all-wheel steer are available. Travels from job to job at road speeds to 30 mph. This rugged, mobile crane is the rig for you if you need big crane capacity without sacrificing the profitable advantages of flexibility, versatility and mobility inherent in all models of Austin-Western hydraulic cranes.

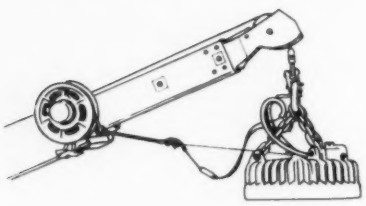
MODEL 210-P

FOR TRUCK OR STATIONARY MOUNTING

7-ton range—The Model 210-P is the famous Austin-Western live 210 hydraulic boom . . . available as a package unit for truck or stationary mounting. Its 18-ft. telescoping boom rotates in a continuous circle; maximum 35-foot boom reach optional; lift capacity is in the 7-ton range. Can't be beat for crane applications requiring a high degree of mobility. This unit, like all other A-W cranes, can be equipped with a wide variety of attachments for extra versatility—such as clamshell, orange peel, maintenance platform, etc.

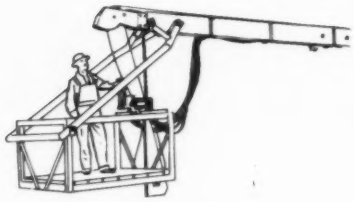


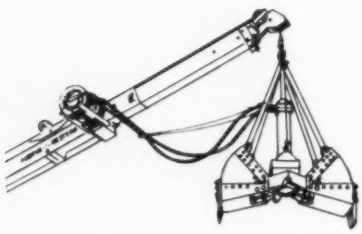
FOR GREATER VERSATILITY—A WIDE CHOICE OF OPTIONAL ATTACHMENTS AND EQUIPMENT



MAGNET

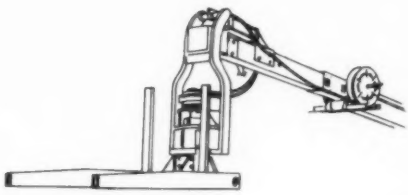
REMOTE CONTROL MAINTENANCE PLATFORM





CLAMSHELL BUCKET

LIFT FORK



Also available for most models:

- ***Orange Peel Bucket***
- ***Cab***
- ***Snow Plow***
- ***Rail Guide Wheels***
- ***Hydraulic Outriggers***
- ***Power Take-Off***
- ***Load Carrying Platform***
- ***Winch***
- ***Bulldozer Blade***
- ***Manual Boom Extensions***
- ***Pintle Hook***

Learn the facts today about the A-W crane best suited to profitably perform your lift, carry or place requirements!

Austin-Western CONSTRUCTION EQUIPMENT DIVISION, AURORA, ILL.

BALDWIN · LIMA · HAMILTON

Power graders • Motor sweepers • Road rollers • Hydraulic cranes

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ALLIS-CHALMERS

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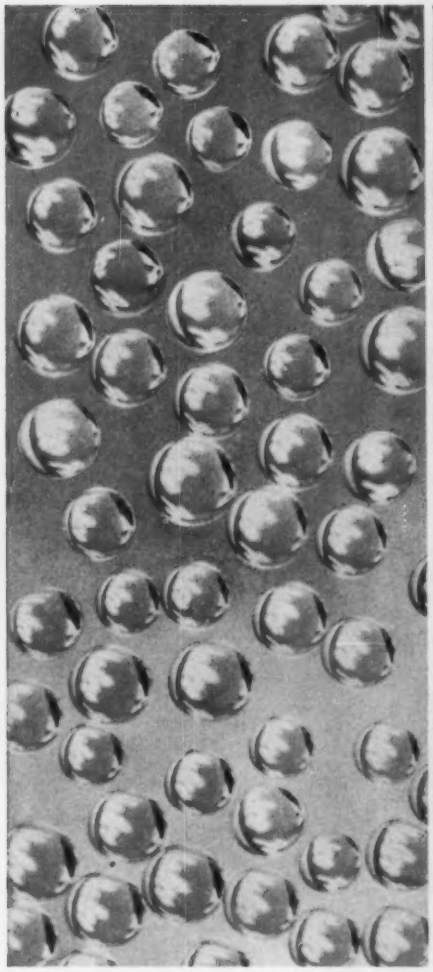
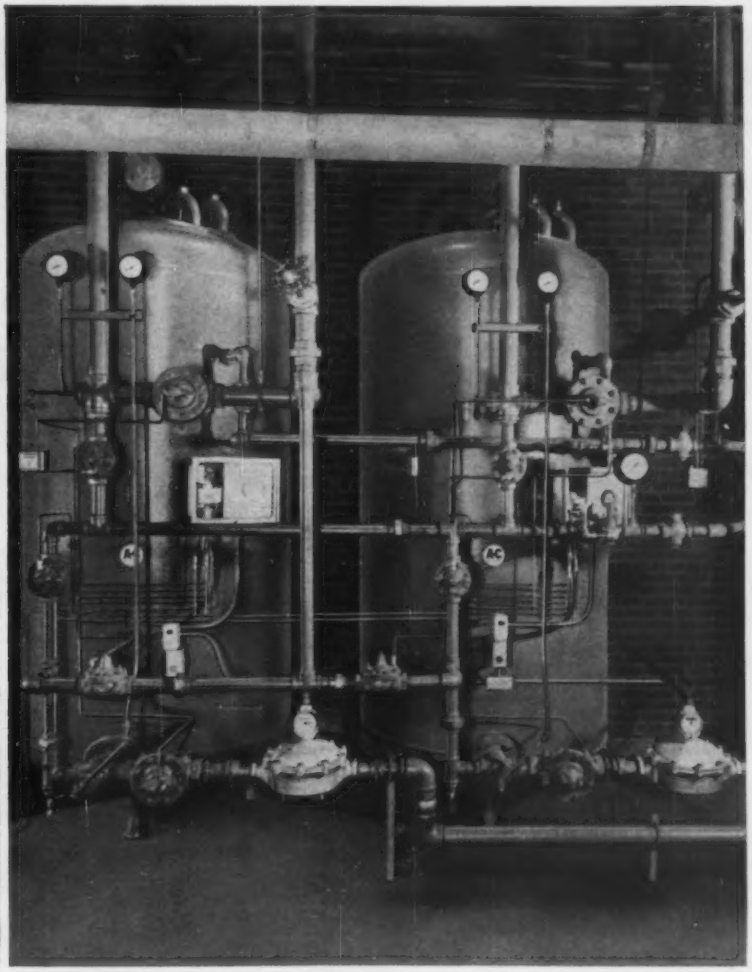




Left, zeolite resin magnified 40 times. **Right,** completely automatic, multiple-valve, dual sodium softeners in Southwest mercantile building.

With Allis-Chalmers Sodium Zeolite water softener in your plant,

hard water vandals turn into "softies"

Fair exchange to an Allis-Chalmers zeolite water softener means a simple switch to sodium ions from the usual hardness present in most water supplies. Calcium and magnesium are the vandals that cause scale in pipes and boilers, clog systems and mean heavy use of cleaning compounds. Zeolite is their natural enemy. But once A-C conditioned, the "softened" water finds ready use in hospitals, institutions, hotels . . . in processing foods and beverages . . . treating municipal water . . . in chemical plants. It ends scaling of manufacturing plant boilers, pipes and heat exchange tubes. A-C standard designs carry a full selection of options to meet any installation problem, local code or custom use. Look to A-C for all of your water conditioning equipment, chemicals and service.

For complete details, call your nearby A-C office or write **Allis-Chalmers,** *Power Equipment Division, Milwaukee 1, Wis.*

One source for all water conditioning facts, chemicals, equipment, service! Write for hot zeolite water softener bulletin 28B7304 . . . sodium zeolite water softener bulletin 28B7107A . . . and deaerator bulletin 28B8853.

For more data on advertised products, use Readers' Service Cards, last page.

made the world over

—and to the same specification

Caposite amosite asbestos is manufactured under supervision to the same uniform specification in all these countries.

Great Britain	by The Cape Asbestos Company Ltd
Canada	by Caposite Insulations Ltd
South Africa	by Cape Asbestos Insulations (Pty) Ltd
Australia	by James Hardie & Company Ltd
France (as 'Isolamiante')	by Isolamiante SA
Italy	by Capamianto SpA
Holland	by J. de Boer & Company
Spain	by Messrs. Eduardo Rosa
Argentina	by Montisol Argentina. SRL
Japan	by Nippon Asbestos Company

Amosite asbestos insulation is also manufactured in U.S.A. under the name of 'Unibestos' by Union Asbestos Rubber Company.

CAPOSITE regd.

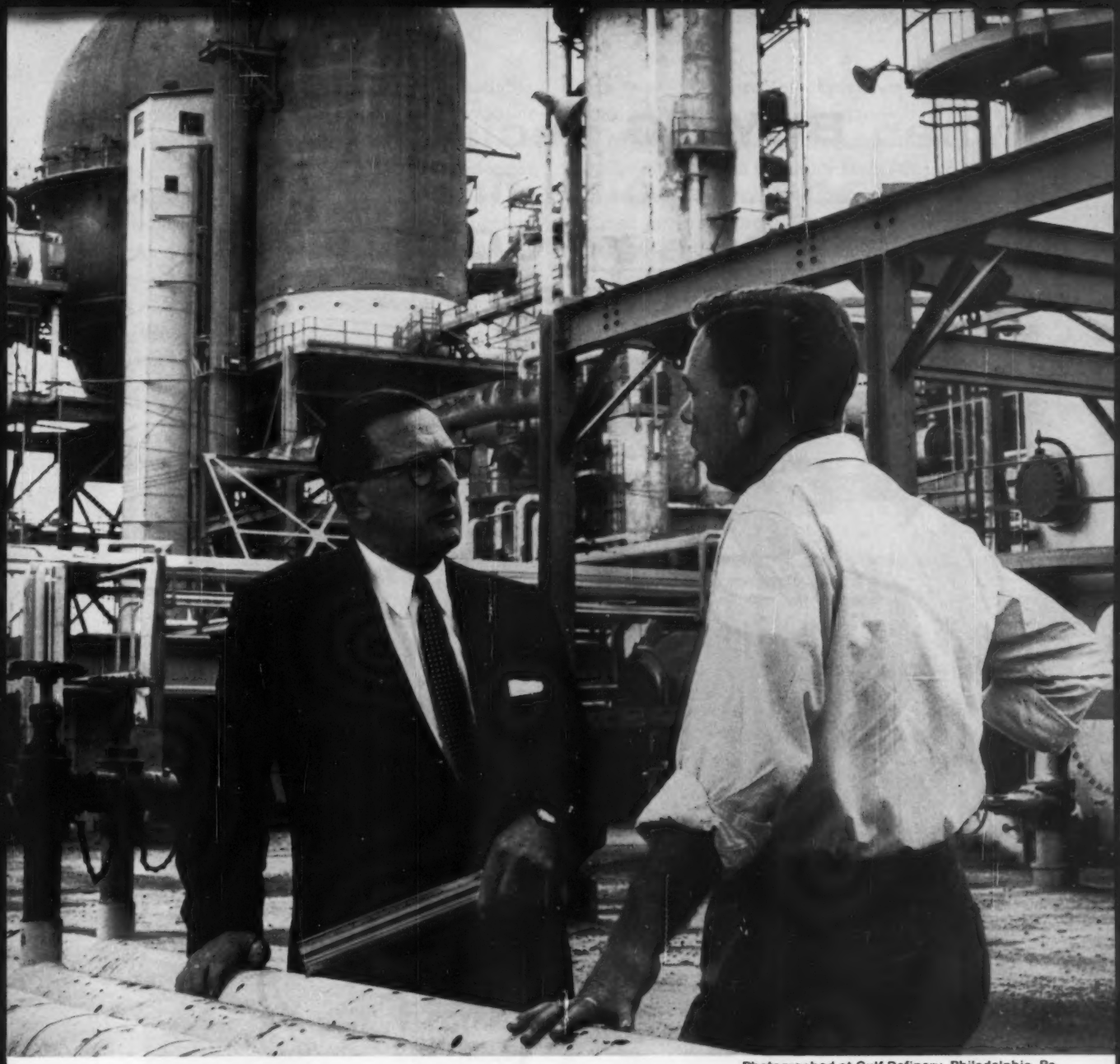
AMOSITE ASBESTOS INSULATION

CAPE

THE **Cape Asbestos** COMPANY LTD 114 & 116 Park St. London W1. Grosvenor 6022

Enquiries to: Cape Asbestos (Canada) Limited, 200 Bloor Street East, Toronto, Ontario. North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois. Capamianto SpA via Sant' Antonino 57, Turin, Italy.

TA.3512



Photographed at Gulf Refinery, Philadelphia, Pa.

How cooperation helped develop a new economy catalyst

Cooperation with refiners at all levels in helping them meet the demand for ever-improved fuels is a guiding principle by which Cyanamid works. This philosophy has aided in the development of many highly efficient catalysts, most recent of which is low-cost Aerocat® 2000 fluid silica alumina cracking catalyst.

Aerocat 2000, compared to natural MS catalysts, offers improved activity stability, higher octane production, superior attrition resistance, more uniform physical properties, and lower coke production.

Cyanamid's sales representatives are prepared to apply the Golden Rule to your problems through the helpful cooperation you want. They are well equipped to be of valuable assistance because of their knowledge and experience in catalytic chemistry, which is backed by a competent organization–a catalyst producer who is also a major chemical manufacturer. Call on your Cyanamid salesman–the man with the Golden Rule.

Basic in catalyst chemistry

CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, N.Y. 20, N.Y.

When **BUYING** decisions are made...you'll find Refinery Catalog **CONSULTED**... Airetool **SPECIFIED**...

Those responsible for keeping America's refineries on stream turn to Airetool for the finest in job-engineered pneumatic tools to fabricate and maintain their tubular equipment. And, they turn to the 28-page Airetool section in the new Refinery Catalog for the latest ideas in pneumatic tools.

Airetool pneumatic equipment gives dependable, 'round-the-clock service that helps keep downtime to a minimum. Tube maintenance costs are cut to the bone and man-power efficiency and production is increased. For more than 30 years, Airetool has been a leader in the design and development of efficient air-powered tools for the petroleum industry. Airetool's pioneering is responsible for many of the pace-setting innovations in pneumatic tools that have produced important savings in time and money for the refining industry. You can depend on Airetool experience . . . service . . . and qualified technical assistance.

AIRETOOL also manufactures a complete line of accessories and specialty tools for even greater speed in tube fabrication and maintenance. In addition, Airetool produces a full line of pneumatic grinders, drills, screwdriver and nutsetter tools.

Meet your tube maintenance requirements by ordering direct from the Refinery Catalog or, for on-the-job advice, call your nearest Airetool representative.

TUBE CLEANERS

A complete line of air motors and cleaning heads for straight and curved tubes, ½" to 24" I.D.

TUBE EXPANDERS

Self-feeding, parallel-rolling expanding tools for every tube size and thickness.

shows you 28 pages of quality equipment!

AIRETROL

Automatically rolls ¼" to 1½" O.D. tubes to uniform accuracy within .001" of pre-setting. One man easily rolls 12 tubes a minute with this lightweight, pneumatic expansion control.

CONDENSER TUBE CLEANERS

New model CC-475 is lightweight for easy, one-man operation that cuts hours off tube cleaning time. Built-in flushing system speeds cutting by cooling head and washing away debris.

ELECTRIC CONTROLS

Roll condenser and heat exchanger tubes to maximum tightness automatically. Eliminates guesswork and steps up production.

PNEUMATIC GRINDERS

Airetool makes a full line of horizontal and vertical pneumatic grinders for heavy duty metal removal, wire wheel work and fine finishing. Model 600-V Vertical Grinder (shown) has revolving wheel guard and is ideal for medium duty grinding. Muffled motors available.

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

PLANTS:
- Airetool Manufacturing Company Springfield, Ohio
- Airetool Nederland, N.V. Vlaardingen, The Netherlands
- Airetool Canada, Ltd. Brantford, Ontario

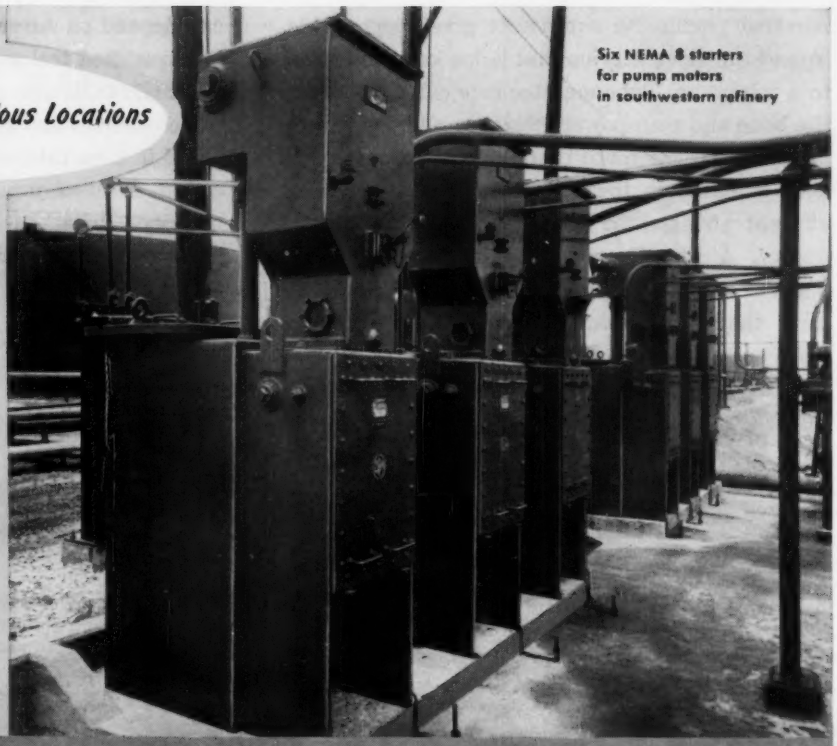
BRANCH OFFICES: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge

REPRESENTATIVES in principal cities of U.S.A., Canada, Mexico, South America, Puerto Rico, Europe, England, Italy, Japan, Hawaii

30 years' experience in pneumatic tools

For more data on advertised products, use Readers' Service Cards, last page.

for Class 1, Group D, Hazardous Locations

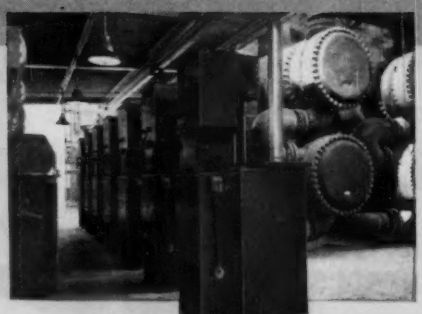


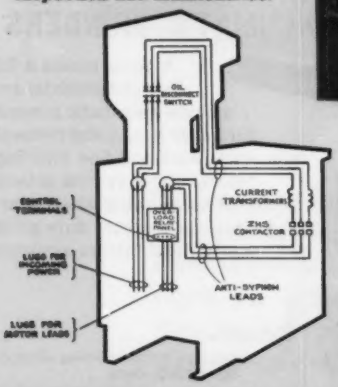
Six NEMA 8 starters for pump motors in southwestern refinery

here's how to

SAVE SPACE and INSTALLATION TIME with EC&M HIGH VOLTAGE STARTERS

SPACE SAVERS! Each of the seven starters in the eastern refinery installation *(at the right)* requires a space of only 2 ft. x 4 ft.—permitting close grouping with maximum accessibility for inspection and maintenance.





YOU SAVE INSTALLATION TIME because every EC&M starter is shipped with all internal wiring complete. *(See diagram at left)* All leads are of anti-syphon construction.

Write for Bulletin 8131 AM

These EC&M 2200-4800 volt Starters are designed for use where hazardous mixtures of air and inflammable gases or vapors are ever-present. NEMA 3R (raintight) enclosure permits mounting indoors, outdoors, or in semi-enclosed location. Load-break oil disconnect switch is self-contained and completely wired into the starter.

Available in two ratings for any power capacity. (*1*) 50,000 KVA (certified) interrupting capacity of EC&M Type ZHS Contactor. (*2*) In VALIMITOR® (volt-ampere-limitor) style... the bus may be of unlimited capacity.

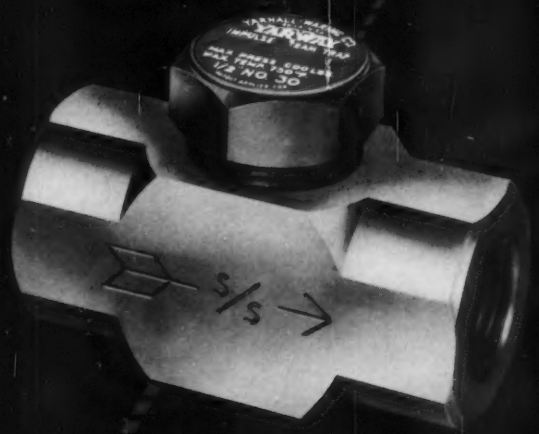
SQUARE D COMPANY

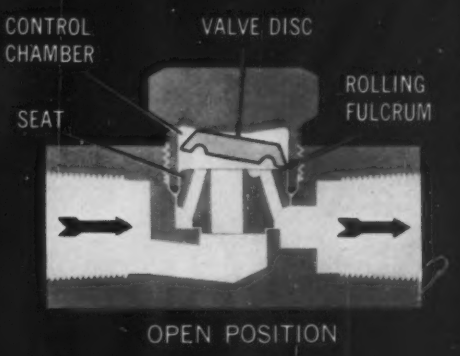
EC&M DIVISION • CLEVELAND 28, OHIO

wherever electricity is distributed and controlled

7936

Do your steam traps give you these 3 advantages?





1. Economy of operation on light loads?

The Yarway No. 30 gives you closer control—discharges condensate at full capacity, closes immediately on steam.

2. Longer service life?

Yarway's lever action reduces impact on valve seat—lessens wear, gives longer operating life. Quieter operation, too!

3. Lower maintenance?

Only Yarway offers an Impulse trap with renewable seat and disc that *can be replaced without removing the trap from the line.*

Why settle for less? Get all three money-saving advantages with Yarway No. 30—plus these time-proven advantages of all Yarway Impulse traps: quick heat-up, even temperatures, small size, stainless steel construction, non-freezing.

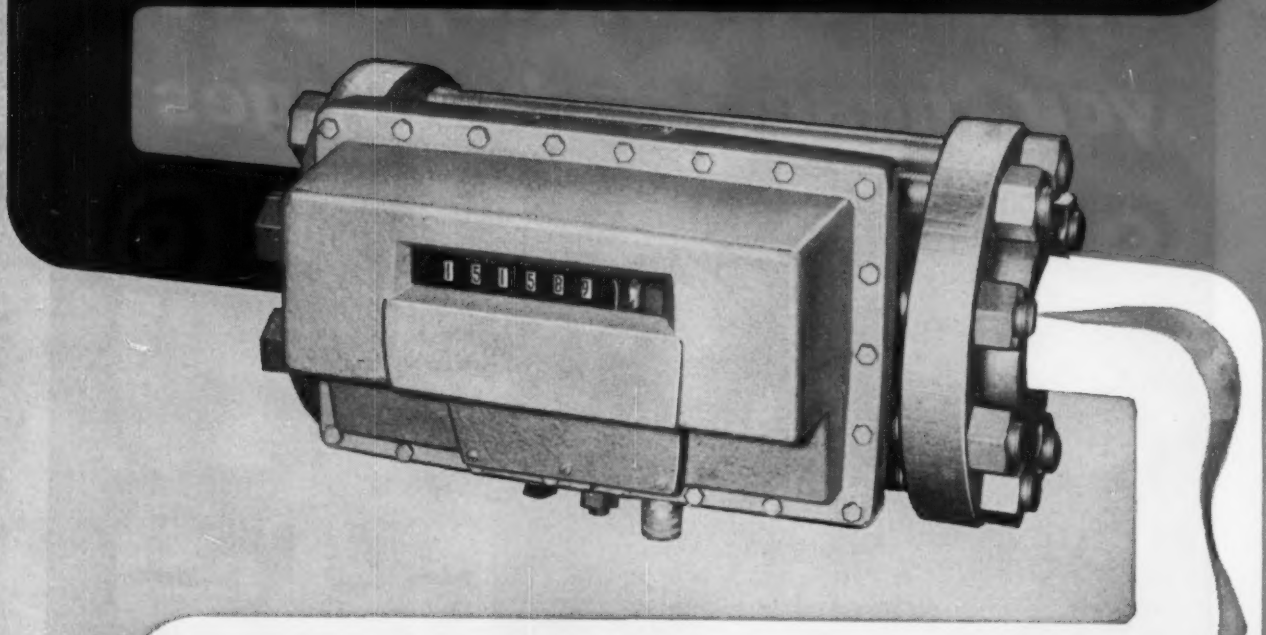
Nearly 1,300,000 Yarway Impulse traps already installed. Stocked and sold by 270 Industrial Distributors. Ask *your* distributor to arrange a free 90-day trial in your plant. Or write us.

YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia 18, Pa.

YARWAY
A MARK OF QUALITY IN STEAM ENGINEERING

For more data on advertised products, use Readers' Service Cards, last page.

AVAILABLE NOW



AVAILABLE NOW

The BS&B-GE Gyro-Integrating True Mass Flowmeter For Natural Gas*

Gives Accurate Gas Flow Measurement Under Wide Variation of Flow Rates, Pressures, Temperatures and Densities

You've read about the True Mass Flowmeter for natural gas. Now, you can put this accurate measuring device to work for you.

True Mass measurement eliminates the problems associated with varying gas densities, super-compressibilities and other physical properties. Measures directly and precisely the gas flow rate in pounds. Readily adapted to automation.

The BS&B Mass Flowmeter makes possible new economies at nearly every level of natural gas measurement. You get large savings not only from reduced calculating time but also from increased accuracy in gas accounting.

Gyro-integration in the meter eliminates chart handling and chart-integration by planimeter. The small, light, self-contained meter is ready for installation — no meter run is required. It's simple to operate and has long service life.

Get highest accuracy from this newest development in mass flow measurement. To prove this meter out for the natural gas industry, BS&B constructed a special prover facility which is believed to be the first positive prover for gases. For your specific application, write . . .

EFFICIENCY OVER 60 YEARS BS&B RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

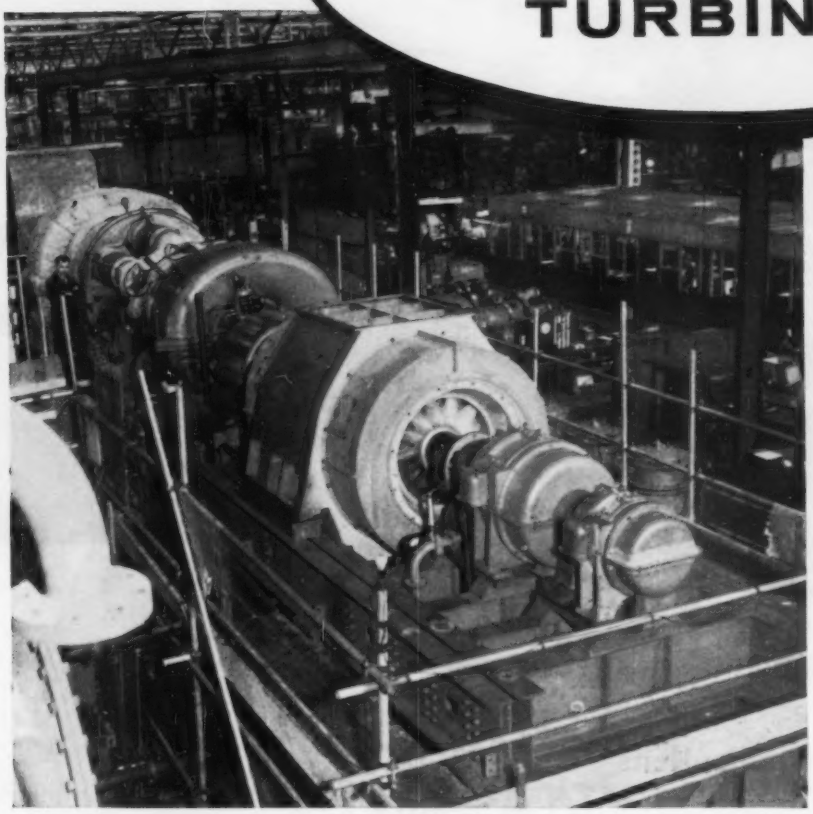
Mass Flowmeter Sales, Dept. 3-F5 P.O. Box 1714, Oklahoma City, Oklahoma

*Manufactured by General Electric
Calibration, Sales and Service by BS&B

NOW WE CAN OFFER

Delivery in 12–15 months

AEI L.5I INDUSTRIAL GAS TURBINES



Already a number of AEI L.51 generating sets with ratings up to 5,000 kW have been ordered, and are now being installed at petroleum plants overseas. The 4,000 kW set shown here was one of three built for installation in Iran.

- QUICK AND SIMPLE STARTING
- SINGLE SHAFT MACHINE ENSURES STABLE REGULATION. 3% maximum speed change on instantaneous application or removal of full load.
- NO WARM-UP PERIOD
- MINIMUM TIME TO FULL LOAD
- ONE-MAN OPERATION FOR STARTING AND RUNNING
- SIMPLE CONCRETE RAFT FOUNDATIONS

RELIABILITY PROVED BY

OVER 23,000 HOURS ON LOAD!

At an oilfield in Venezeula, an AEI gas turbine set has already completed over 23,000 *hours* on base load duty. A similar AEI unit has been installed for stand-by and peak load duties at a British water pumping station.

For further particulars write to AEI Turbine-Generator Division, Trafford Park, Manchester 17, or to your local AEI Office.

AEI Associated Electrical Industries Limited

Turbine-Generator Division

MANCHESTER & RUGBY, ENGLAND, GLASGOW, SCOTLAND, LARNE, NORTHERN IRELAND

B/J907

For more data on advertised products, use Readers' Service Cards, last page.

COMPARE

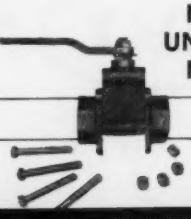
THE ECON-O-MISER BALL VALVE...

The most advanced replacement valve for ON-OFF applications

Engineered design simplicity provides superior performance plus real dollar savings. • Remove 4 bolts—the center section lifts out—unions are eliminated. Service time and cost are reduced to a matter of minutes and pennies, and the valve is right back in operation. Costly spare parts are a thing of the past. • The Econ-O-Miser Ball Valve answers thousands of difficult application problems—simply—efficiently. Available from ¼″ through 6″ size range, it is ideally suited to difficult media, because of its smooth round flow and quarter-turn operation. • If you're interested in valves, you're interested in the Econ-O-Miser Ball Valve. Complete, up-to-date technical information is yours for the asking.

WORCESTER VALVE CO., INC.

16 PARKER STREET, WORCESTER, MASS.



NO UNION NECESSARY!

New FLAKED Super Filmeen obsoletes all other filming amines

Totally effective, easiest to handle and use, most economical—this is the verdict of power engineers on the latest development from Dearborn's research laboratories—Super Filmeen in FLAKE form.

This free flowing, finely divided waxy flake is easily handled and weighed; readily dispersible... 31% more active than ordinary octadecylamine acetate... not subject to dehydration at super-heated steam temperatures... will not hydrolyze to acetic acid... remains alkaline in feed solutions.

Shipped as 100% active ingredients—saves on freight.

Update YOUR condensate return line protection with Super Filmeen. Call your Dearborn Engineer or send for detailed Technical Bulletin today!

DEARBORN CHEMICAL COMPANY

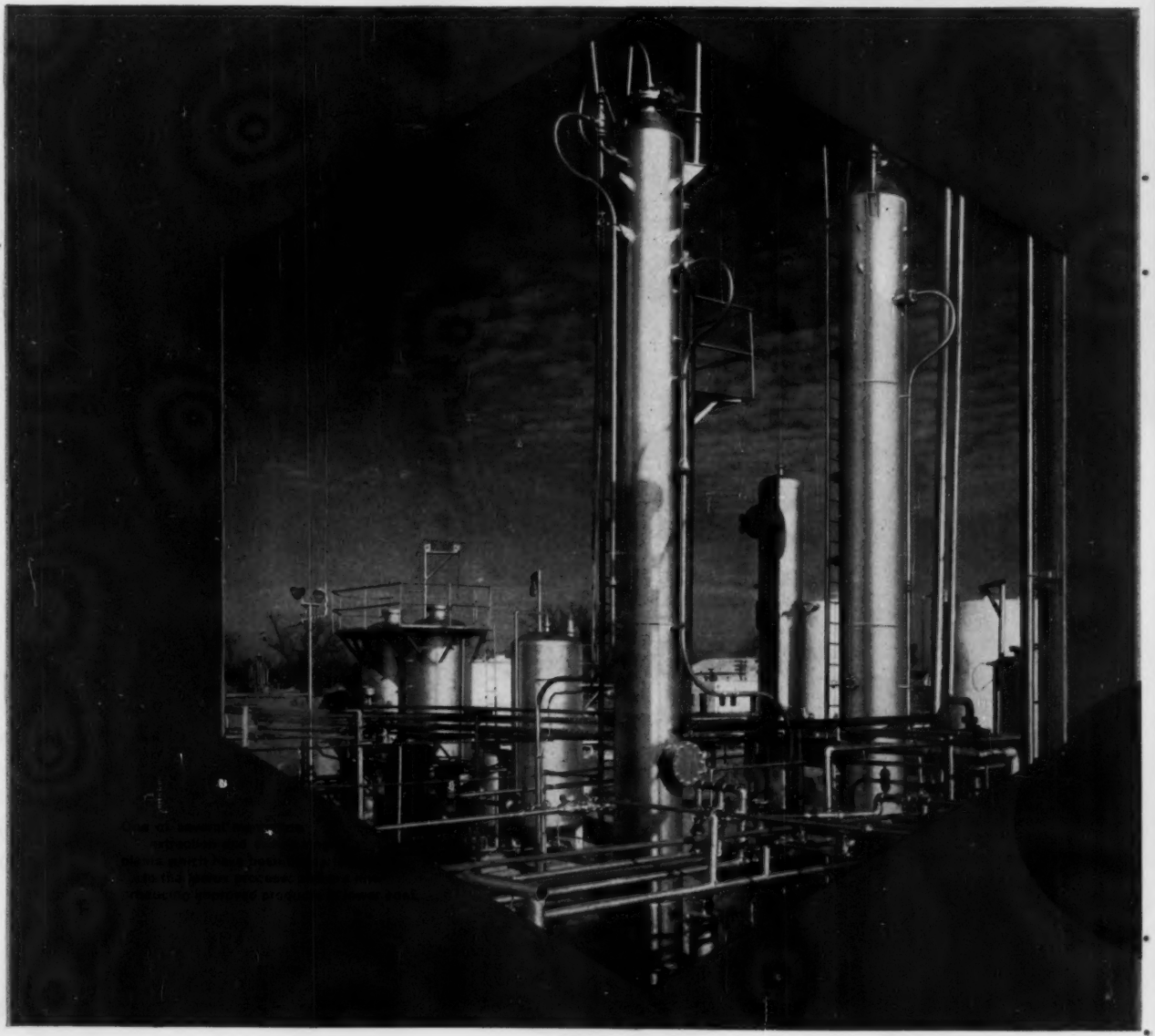
Executive Offices: Merchandise Mart, Chicago 54
Plants and Laboratories: Chicago • Linden, N. J. • Los Angeles
Toronto • Honolulu • Havana • Buenos Aires

pioneer in the science of corrosion control

For more data on advertised products, use Readers' Service Cards, last page.

and NOW...
a new
dual-function
process...

ME



For more data on advertised products, use Readers' Service Cards, last page.

'62 COULD BE
THE YEAR FOR YOU!

ROX

Trademark

1. Extracts mercaptans for gasoline and lighter fractions
2. Sweetens pentane, hexane, gasoline, jet fuel, kerosene

EXISTING TREATING EQUIPMENT can be converted to Merox operation at low cost to provide greatly improved efficiency and substantially reduced operating costs.

With Merox, mercaptans are extracted from the sour stream and are converted by oxidation to a doctor sweet product. To some light stocks sweetening is subsequent. Heavier fractions above boiling range of gasoline or doctor sweetening, Merox converts the harmful mercaptans to innocuous reaction products in the treated oil.

The Merox catalyst permits the reaction to use ordinary air to convert the mercaptans.

WHERE TO IMPROVE PRODUCT QUALITY, CUT COSTS WITH MEROX

SOUR PROPANE and butane streams—to remove mercaptans prior to polymerization or alkylation.

SOUR PENTANE and hexane streams—to remove mercaptans or to sweeten only.

LT. STR. RUN GASOLINES—extract mercaptans and sweeten, to improve TEL susceptibility.

CRACKED GASOLINES that are hard to sweeten—readily treated with Merox.

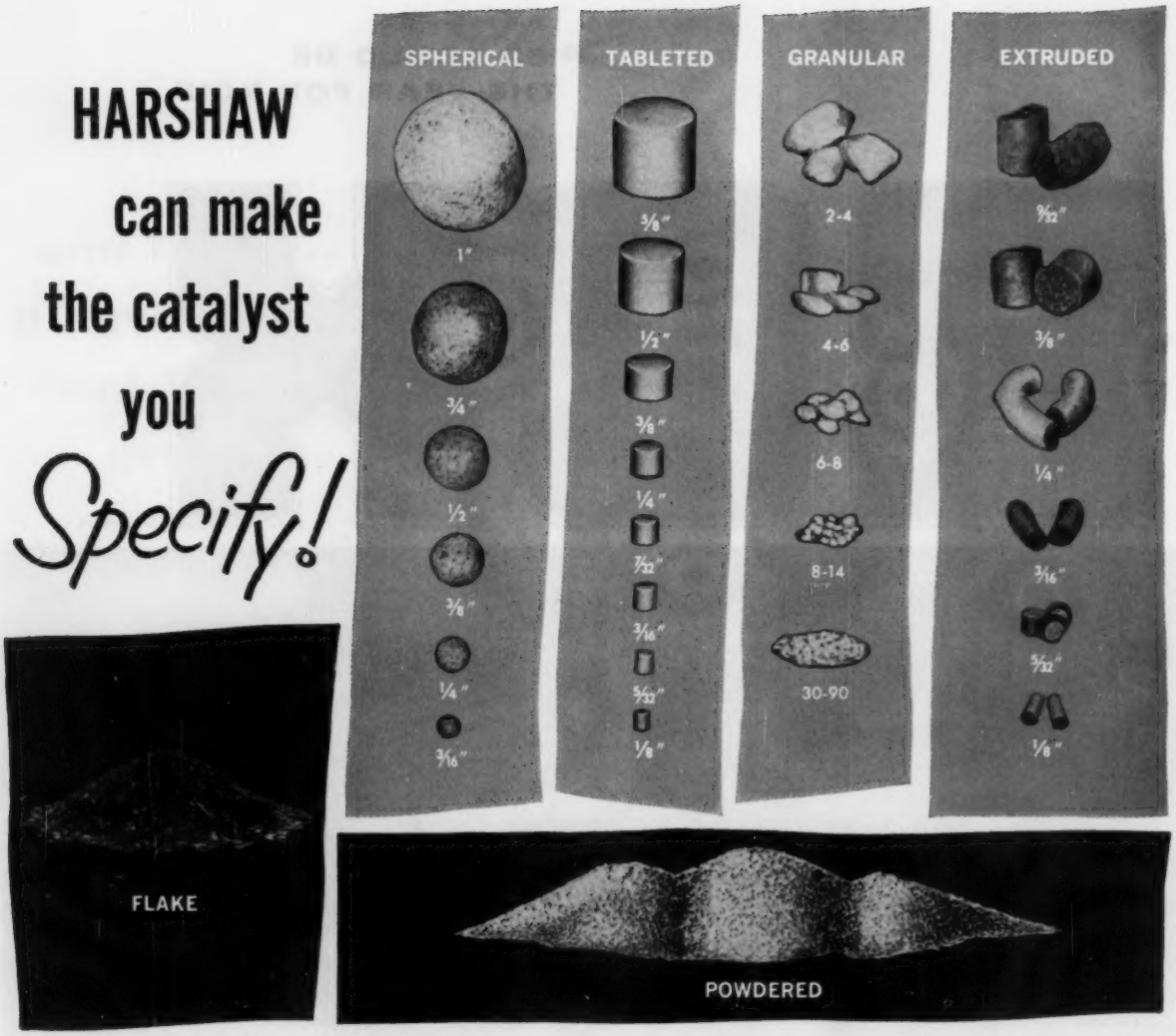
THERMALLY AND CATALYTICALLY CRACKED GASOLINES of low mercaptan content that are not susceptible to inhibitor sweetening—readily sweetened by Merox.

JET FUELS—sweetened very economically, or reduced to 0.001% specs.

HIGHER BOILING STOCKS in No. 2 fuel oil range—can be partially sweetened to meet mercaptan specs.

UOP

HARSHAW can make the catalyst you *Specify!*



HARSHAW
has the facilities for producing carload quantities of
PREFORMED CATALYSTS
to fit special process requirements

Hydroforming	Dehydration
Cyclization	Desulphurization
Oxidation	Alkylation
Dehydrogenation	Isomerization
Hydrogenation	

Write for FREE Booklet, "HARSHAW CATALYSTS"

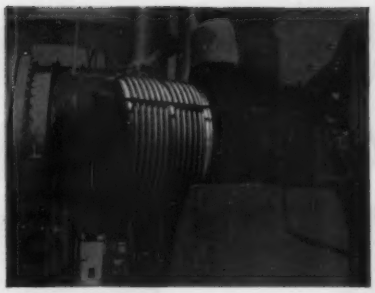
CATALYTIC CHEMICALS SUPPLIED BY HARSHAW

Aluminum Nitrate		Cobalt Nitrate
Copper Nitrate		Manganese Nitrate Solution
Metallic Soaps (Cobalt, Manganese)		
Nickel Carbonate	Nickel Formate	Nickel Nitrate
Nickel Sulfate	Sodium Methoxide	Zinc Nitrate

Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

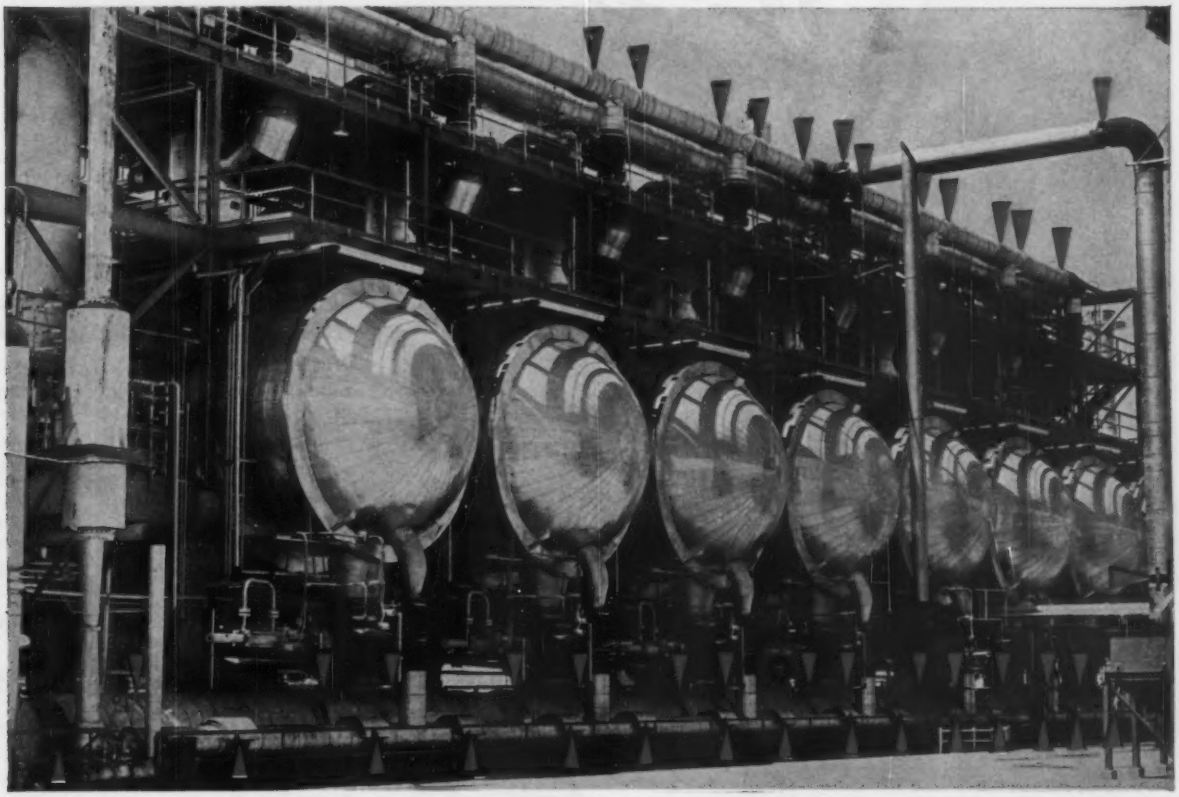
THE HARSHAW CHEMICAL CO.
1945 EAST 97th STREET • CLEVELAND 6, OHIO
Chicago • Cincinnati • Cleveland • Detroit • Hastings-On-Hudson
Houston • Los Angeles • Philadelphia • Pittsburgh

85½ in. dia. expansion joint connecting quench and pre-quench towers. Pinned structural ties permit expansion joint to absorb axial and differential vertical movement.



48 in. dia. expansion joint at compressor discharge. Double bellows permit large axial movement. Internal sleeve guide provides for stability, minimum pressure drop.

54 in. dia. hinged expansion joints in loop to pre-quench tower. They absorb 5⅜ in. vertical expansion and 7⅜ in. horizontal expansion due to 1200°F temperature in reactor header.



125 ZALLEA EXPANSION JOINTS, 125 demands for maximum reliability

Expansion joints, specially engineered and designed by Zallea, solve problems of space, heat and flow for Odessa Butadiene Co., Odessa, Texas.

Large-diameter piping (up to 72 in. dia.), with short, straight runs and critical flow conditions, posed new design problems. High temperature operation (1200°F) required minimum loading on sensitive equipment. Open-air construction, with few load carrying members dictated maximum stability of expansion joints with minimum use of external guides and anchors to support pipe weight and resist wind loading.

To solve these problems called for a competent, close-working team of process, piping and structural engineers from Fluor Corp. Ltd., design engineers from Odessa Butadiene Co., and application engineers from Zallea.

Result: A compact, reliable piping-expansion joint system that permitted containment of an efficient, 50,000 ton per year unit in an area whose largest dimension is a few hundred feet.

This is another example of how Zallea experience in handling critical, complex Expansion Joint applications can save time and money. For more facts, call us . . . or write for catalog 56.

ZALLEA BROTHERS, Taylor and Locust Sts., Wilmington 99, Del.

Zallea **FOR MAXIMUM RELIABILITY**

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS

For more data on advertised products, use Readers' Service Cards, last page.

KELLOGG'S WIDENING WORLD

Reduces Unit Investment and Operating Costs

Kellogg Alkylation Units Throughout The Refining World

ARGENTINA	
Lujan de Cuyo, Mendoza	1,600 BPD
AUSTRALIA	
Melbourne	2,000 BPD
Sydney	3,400 BPD*
CANADA	
Vancouver, B.C.	1,000 BPD
Calgary, Alberta	1,500 BPD
Montreal, Quebec	1,600 BPD
CHILE	
Concon	1,100 BPD
IRAN	
Abadan	6,000 BPD
SAUDI ARABIA	
Ras Tanara	1,400 BPD
UNITED STATES	
East Chicago, Ind.	2,600 BPD
Beaumont, Texas	5,000 BPD
Texas City, Texas	3,500 BPD
Whiting, Ind.	5,000 BPD
Lake Charles, La.	12,750 BPD
Lake Charles, La.	10,675 BPD

FOR REFINERS wishing to increase their barrel octane for the lowest optimum over-all expenditure, Kellogg can design and build an alkylation unit which will utilize normal refinery feeds, yield the desired quantity and quality of alkylate, yet cost less to install and operate than ever before.

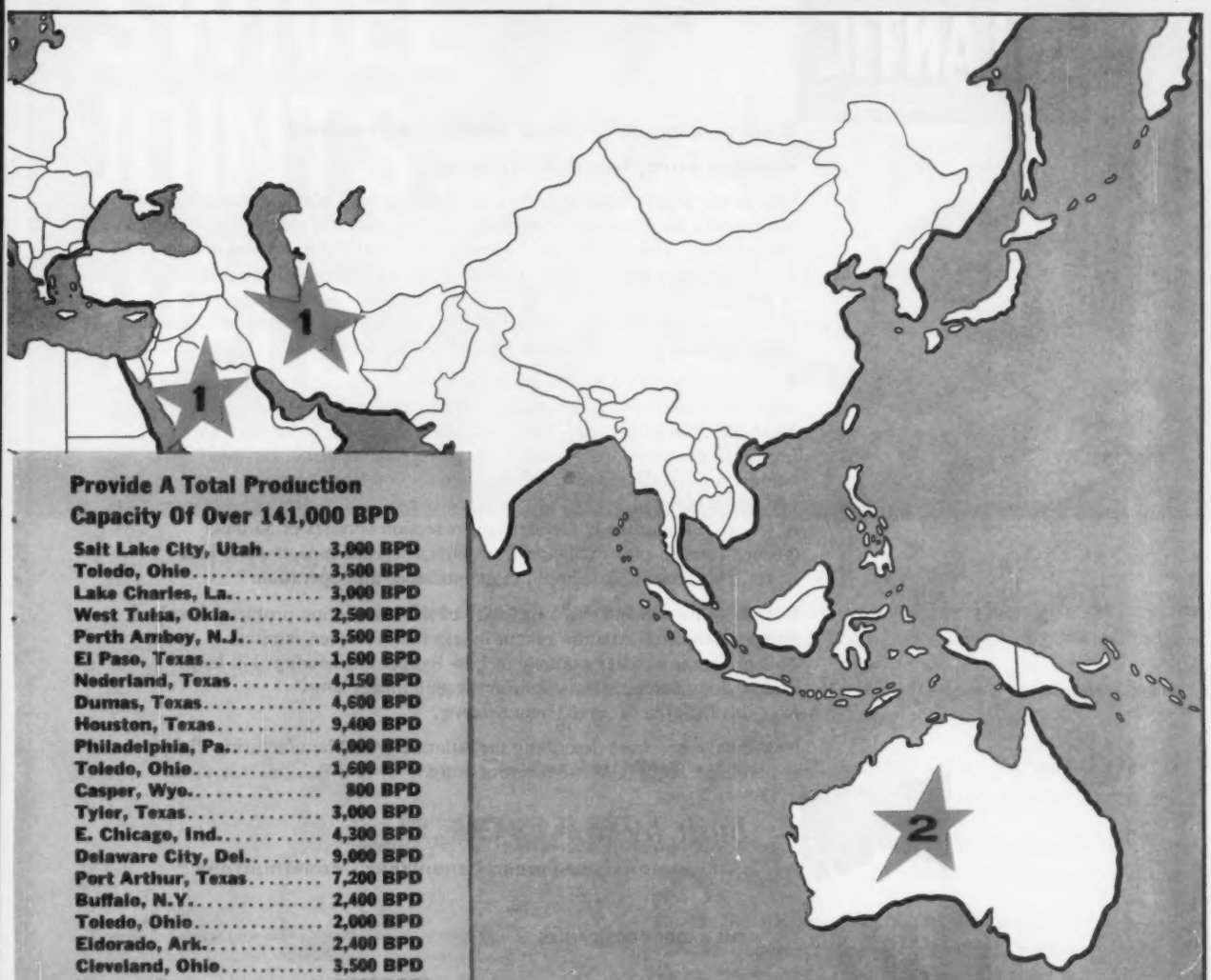
This economic approach to a high octane product for the gasoline pool, when and as required, is made possible through Kellogg's experience to date in engineering and building 38 alkylation units of various designs, for both large and small refiners, in 6 foreign countries as well as in 13 States at home.

The most efficient, most economical, and most flexible of these alkylation units are those utilizing Kellogg's most recent sulfuric acid, multi-stage cascade reactor design. Whether for 500 or 15,000 BPD, Kellogg can undertake the entire design, procurement, and construction of one of these units for a lump-sum contract.

For more data on advertised products, use Readers' Service Cards, last page.

OF ALKYLATION EXPERIENCE

—Increases Range of Feedstocks and Yields



Provide A Total Production Capacity Of Over 141,000 BPD

Salt Lake City, Utah	3,000 BPD
Toledo, Ohio	3,500 BPD
Lake Charles, La.	3,000 BPD
West Tulsa, Okla.	2,500 BPD
Perth Amboy, N.J.	3,500 BPD
El Paso, Texas	1,600 BPD
Nederland, Texas	4,150 BPD
Dumas, Texas	4,600 BPD
Houston, Texas	9,400 BPD
Philadelphia, Pa.	4,000 BPD
Toledo, Ohio	1,600 BPD
Casper, Wyo.	800 BPD
Tyler, Texas	3,000 BPD
E. Chicago, Ind.	4,300 BPD
Delaware City, Del.	9,000 BPD
Port Arthur, Texas	7,200 BPD
Buffalo, N.Y.	2,400 BPD
Toledo, Ohio	2,000 BPD
Eldorado, Ark.	2,400 BPD
Cleveland, Ohio	3,500 BPD
Warren, Pa.	1,100 BPD*
Robinson, Ill.	2,800 BPD
Toledo, Ohio	3,500 BPD

**Future*

Designed to operate on butylene, propylene, amylenes, or a combination feed, these new units offer many advantages over other models. They can produce an LPG product, as well as high octane alkylate, without supplementary towers or equipment. They reduce corrosion to a minimum without extensive use of expensive chemicals. They are extremely low on acid consumption—using, for example, less than 0.3 sulfuric acid per gallon of alkylate. They are adaptable to seasonal demands—capable of maintaining peak barrel octane production at minimum operating cost.

Kellogg welcomes the opportunity to discuss the details of its alkylation process with you.

THE M. W. KELLOGG COMPANY

711 Third Ave., New York 17 *A subsidiary of Pullman Incorporated*

Offices of Kellogg subsidiary companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires

For more data on advertised products, use Readers' Service Cards, last page.

built by Badger for

ATLANTIC

220 million lb/yr. wax plant of advanced design completed in 61 weeks

One of the largest, most flexible wax manufacturing plants ever constructed has recently been completed by Badger at the Atlantic Refining Company's Philadelphia refinery. The classic and widely used MEK solvent process* was the starting point for this ultra-modern plant. From there, Badger engineers created an unusually versatile design . . . a plant capable of processing eight different feedstocks through fourteen operations to produce corresponding grades of paraffin waxes (oil content 0.2%).

Plant capacity (265 tons/day) and the number and variety of processing steps made economical design a major engineering undertaking. Examples: the filter section includes fourteen 700 sq. ft. units of an improved design — the largest in the petroleum industry; the two compressors in the massive refrigeration section have a combined rating of 5,800 h.p. — equivalent to the capacity required to produce 4,200 pounds of ice per minute; the chiller-exchanger section consists of 33 units (sixteen scraped-pipe exchangers, seventeen scraped-pipe chillers) in a novel arrangement that simplifies maintenance and operation.

In spite of its size and the complexity of the engineering problems involved, Badger completed Atlantic's plant in less than fourteen months. This project is another example of how Badger engineering skill helps leading companies get more efficient, economical plants. Isn't this the type of service you deserve?

New 8-page brochure describing the Atlantic Wax Manufacturing Plant available on request. Write for your copy.

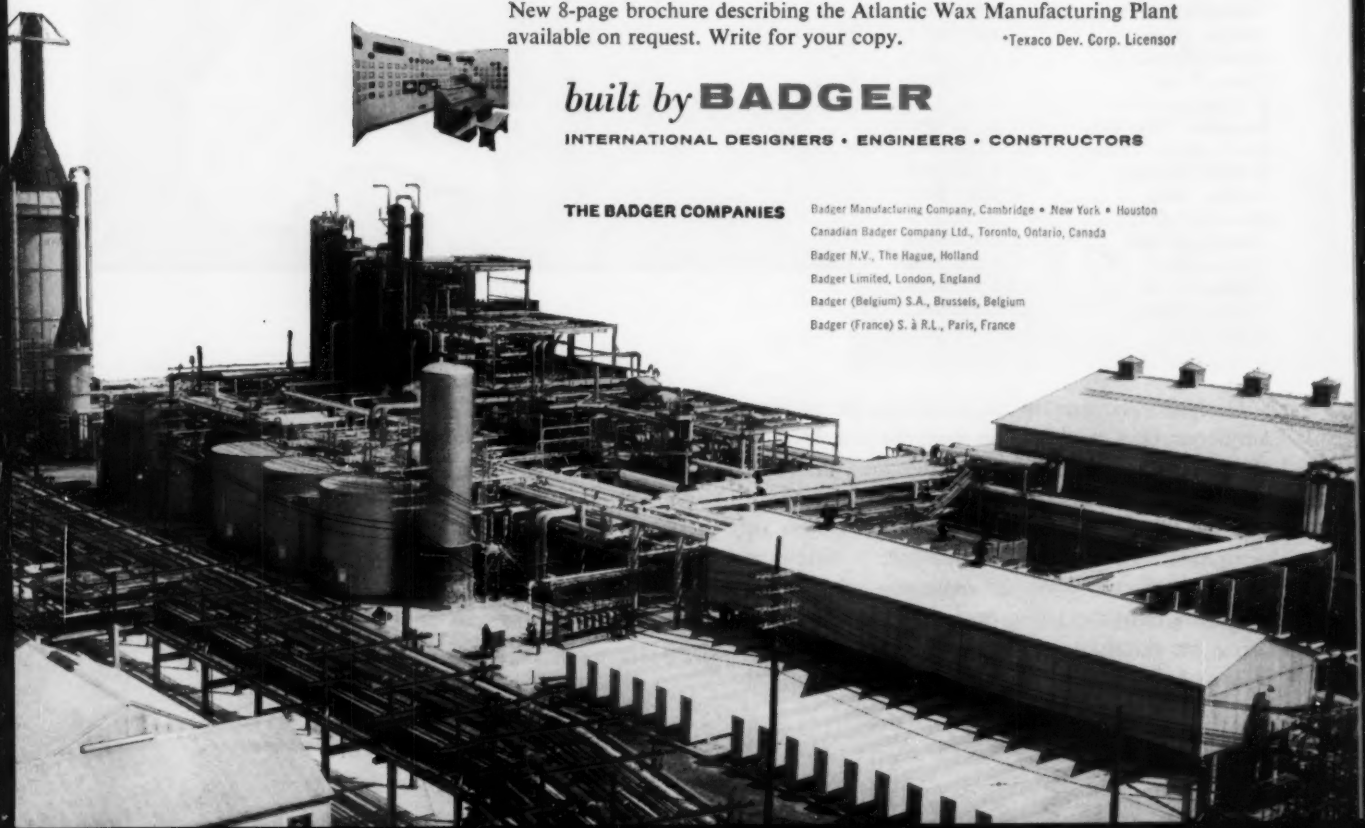
*Texaco Dev. Corp. Licensor

built by **BADGER**

INTERNATIONAL DESIGNERS • ENGINEERS • CONSTRUCTORS

THE BADGER COMPANIES

Badger Manufacturing Company, Cambridge • New York • Houston
Canadian Badger Company Ltd., Toronto, Ontario, Canada
Badger N.V., The Hague, Holland
Badger Limited, London, England
Badger (Belgium) S.A., Brussels, Belgium
Badger (France) S. à R.L., Paris, France



Continental-Emsco

SWIVEL JOINTS..

modern joints you can

WELD

into the line!

Now you can say..

goodbye to leaky threads C-E joints welded into loading arms eliminate excessive maintenance costs caused by dripping caustic fluids.

goodbye to costly flanges C-E weldable joints eliminate need for flanged connections when fabricating loading arms.

goodbye to higher installation costs C-E weldable joints are easier and faster to install, lower priced and stronger, too.

goodbye to time-consuming packing replacement C-E weldable joints can be repacked when necessary without removal from loading arms.

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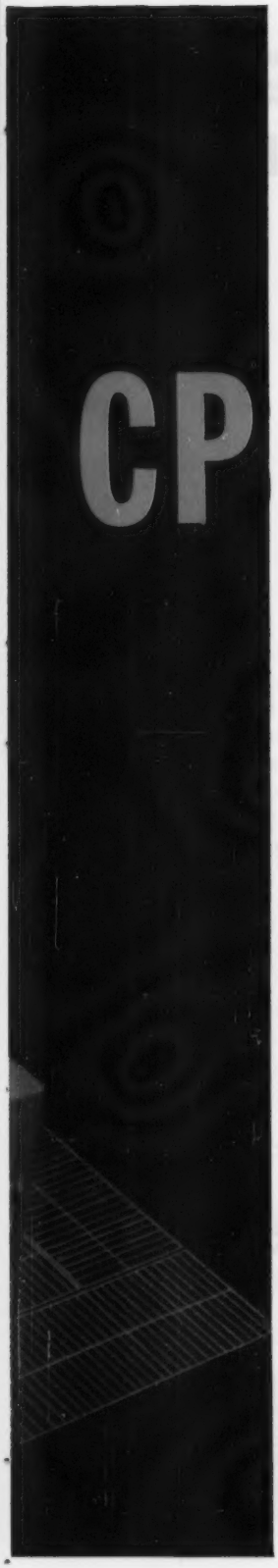

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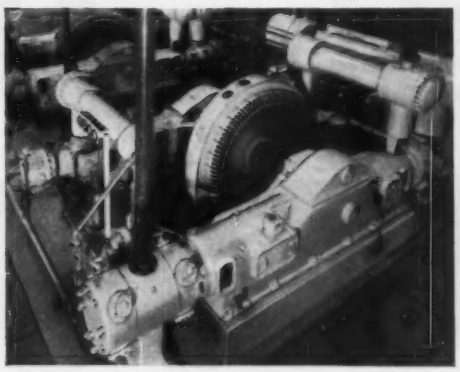

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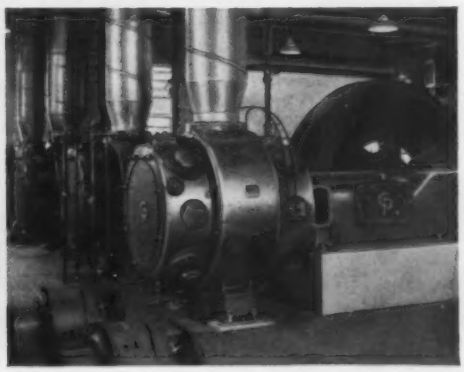

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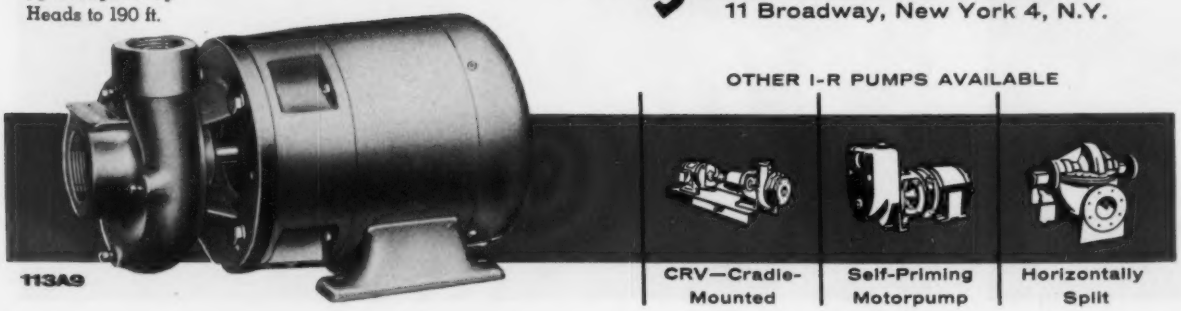

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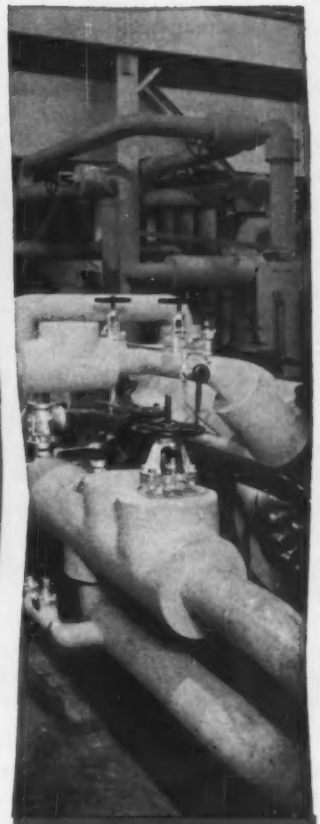

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HERE'S WHY:

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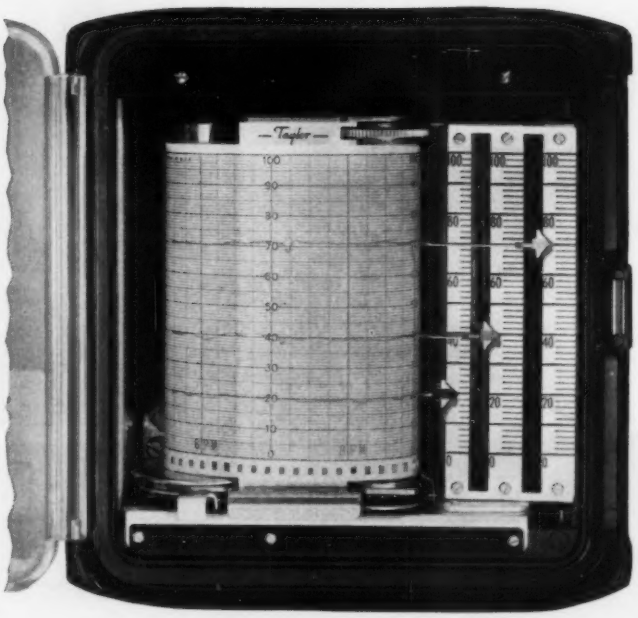

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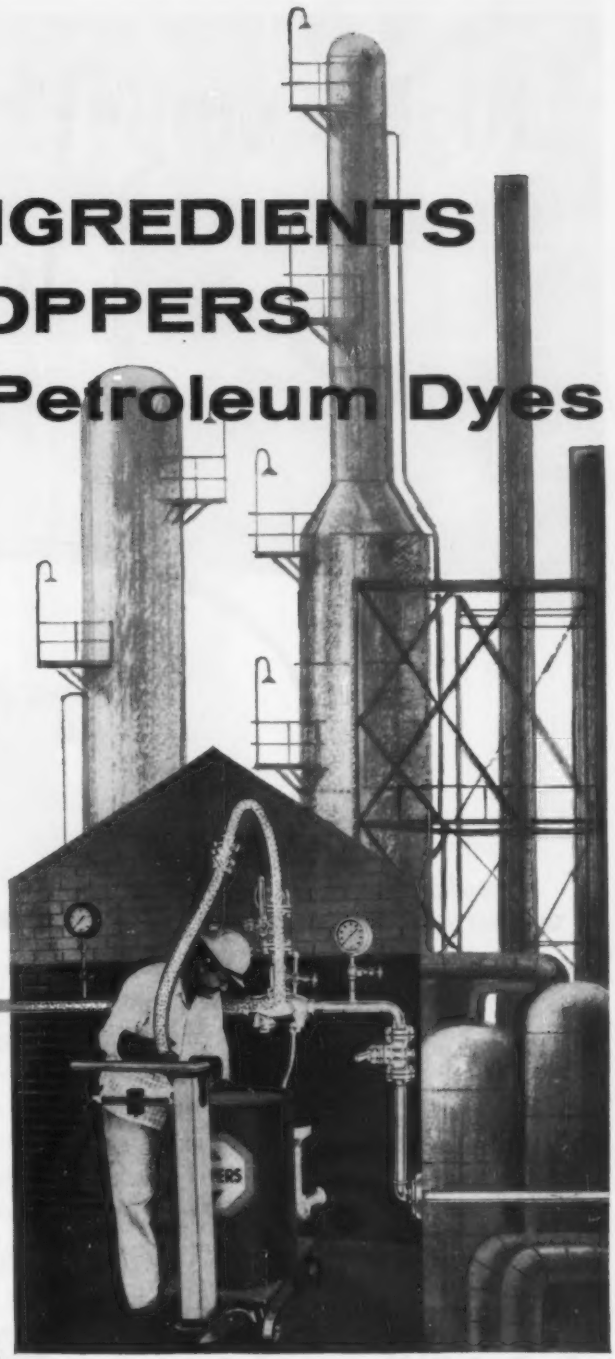

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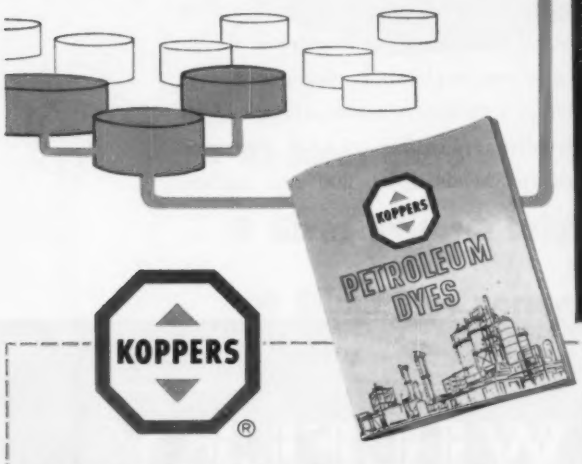

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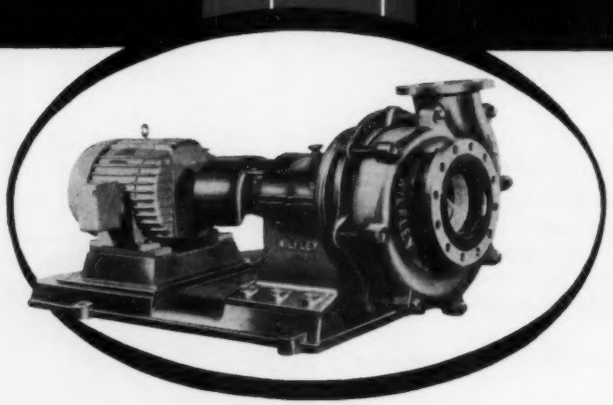

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HELPFUL WATER CONDITIONING DATA FROM BETZ

SLIME CONTROL WITH CHLORINE

Judicious use of chlorine and the supplemental use of other biocides will extend cooling tower life

A RECENT SURVEY of open recirculating cooling water systems has revealed that more than ninety percent of these systems require treatment for prevention of biological fouling in order to avoid loss in heat transfer and to prevent accelerated corrosion. The survey further revealed that in the majority of these systems chlorine is used for slime control or is supplemented by a non-oxidizing type biocide. Chlorine is used widely because it is effective, fast acting and economical. The increased trend toward the supplemental use of non-oxidizing biocides is due to the adverse effects chlorine has on cooling tower wood.

Chlorination

There is ample evidence that chemical attack renders the wood more susceptible to biological attack. It has been definitely established that excessive chlorination will cause delignification of cooling tower wood. Delignification also occurs when excessive alkalinity is maintained in the circulating water. The combination of excessive alkalinity and chlorine will produce severe chemical attack. Both chemical and biological attack have been more prevalent in towers that use chlorine alone for prevention of slime. Conversely, the incidence and frequency of chemical and biological attack has been at a minimum in systems that use non-oxidizing biocides alone for slime control.

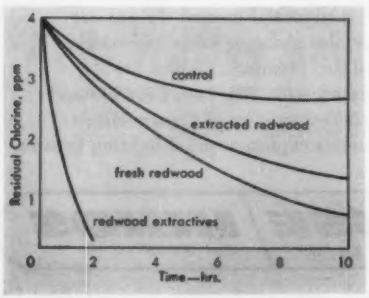


Figure 1—Reaction rate of chlorine with redwood and redwood extractives.

It may seem contradictory that an effective slime control agent such as chlorine pre-disposes wood to biological attack. Figure 1 shows the rate of reaction of chlorine with redwood and redwood extractives. In addition to reacting with the lignin components of the wood, chlorine will react with the natural extractives. The rapid removal or destruction of nature's toxicants from the wood renders the wood more susceptible to biological attack.

Undoubtedly, many of the systems that have shown rapid or excessive attack from the use of chlorine have lacked adequate control of chlorination. In many of these cases, the chlorine residual has been improperly determined, determined at the wrong point for proper control, not checked frequently enough or neglected entirely. In the majority of the systems using chlorine for slime control, the chlorine residual is checked (as it should be) in the water returning to the tower *not after the water cascades through the tower*. The water in passing through the tower will have its chlorine residual decreased to very low values or depleted entirely. The reduction in chlorine residual occurs partially due to aeration but mainly through reaction with the wood. Where attempts have been made to control chlorine residuals after the water has passed through the tower, excessive chlorine residuals have been permitted to contact the wood and accelerated chemical attack has been the result.

In instances where intermittent chlorination has been practiced, initially the duration of the chlorination period and the rate of chlorination may have been established properly by testing for the chlorine residual. However, all too often, after initially establishing the rate and duration, infrequent or no further testing for chlorine residual is made. Since the chlorine demand of most circulating waters will vary, this practice has led alternately to low residuals and poor slime control or to high residuals and excessive attack of the wood.

While the adverse effects of chlorine on cooling tower wood have been established, it has been apparent that chlorination can be used judiciously and effectively, particularly if supplemented by non-oxidizing type biocide. The chemical attack of cooling tower wood can be held to a minimum by avoiding chlorine residuals greater than 1.0 ppm and preferably by controlling residuals in the range of 0.3 to 0.5 ppm. The pH of the circulating water has an important bearing. Where chlorination is practiced, it is essential that a pH greater than 8.0 be avoided and preferably the pH be maintained in a range of 6.0-7.0.

Non-oxidizing Biocides

The prevalence of biological attack of cooling tower wood in systems using chlorination has led to the conclusion that chemical attack predisposes the wood to biological attack. In cases where carefully controlled chlorination is practiced and chemical attack of the wood surfaces is low, studies have been conducted to check the incidence of fungi on the surfaces of the wood and in the subsurface sections. Microtome sections of the wood, such as that shown in Figure 2, reveal a high incidence of fungi in the wood from the fill and plenum areas of the tower. These studies indicate that chlorination alone is not effective in controlling the organisms responsible for attack of wood. The judicious use of chlorination requires low residuals be maintained. As the water cascades through the tower, these residuals are depleted. The air-borne organisms therefore can and do accumulate

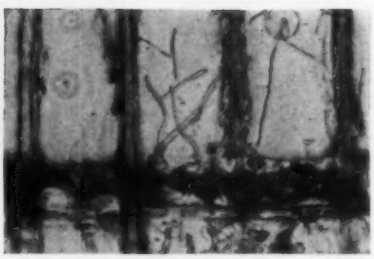


Figure 2—Fungus hyphae growing through wood cells.

readily on the surfaces of the wood and grow and develop in the subsurface sections. Similar studies conducted for systems that use non-oxidizing biocides alone for slime control show that the incidence of fungi on the wood surfaces is negligible. Since these biocides do not react with the wood, they are able to penetrate the wood surfaces and effectively control the causal organisms. Accordingly, the supplemental use of non-oxidizing biocides is necessary where chlorination is practiced to assure maximum tower life.

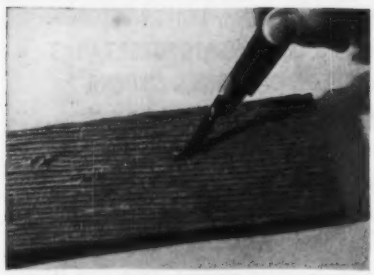
One other shortcoming of chlorination has been noted in systems that have large tower sumps wherein the water remains relatively stagnant. Small chlorine residuals do not carry down into the lower depths of the tower sump. Muck and debris accumulate in these areas and provide ample food for growth and development of microorganisms.

	Bacterial Counts			Fungi
Sampling Point	Total	Spore	Sulfate Reducing	—
Circulating water	5	1	0	1
tower sump	2,900,000	63	5	10
Circulating water	6	1	0	0
tower sump	5,600,000	910	2	100

(Counts—no. per ml.)

Table I

AND NON-OXIDIZING BIOCIDES



Chemical attack showing ridged and fibrillated wood surface.

Table I shows the microbiological populations for samples taken of the circulating water and from the lower depths of the tower sump. In addition to the high bacteria counts, sulfate-reducing bacteria and fungi were present. Where chlorination is practiced, particularly on an intermittent basis, these areas serve as a point of inoculation. The supplemental use of non-oxidizing biocides will serve to eliminate this point of infection.

In systems where the chlorine demand of the water varies widely due to organic matter present in the makeup, from periodic process contamination, or from changes in direction of the wind carrying air-borne contaminants such as hydrogen sulfide, maintaining the desired chlorine residual will be difficult. The supplemental use of non-oxidizing biocides which are not affected by these contaminants will simplify control. In cases where the chlorine demand is continuously high, the economic advantage of chlorine can disappear and the use of non-oxidizing biocides on a continuous basis would be justified.

Where the cooling water system is relatively small or where there is only infrequent need for slime control agents, it is convenient to employ the non-oxidizing biocides alone. These materials are available in liquid, powder or briquette form and do not require special feeding facilities. The investment for chlorine feeding equipment and the maintenance costs for such equipment would not be justified. In addition, the application of the non-oxidizing biocides does not require elaborate feeding equipment or rigid control, and the cost of application is therefore negligible.

The choice of chlorine for control of slime formation in large cooling water systems is a valid one. However, the application of chlorine must be controlled carefully to avoid adverse effects on wood. It should be realized that where chlorination alone is used, the complete microbiological problem of the cooling water system is not controlled. Normally, slime control is associated with the need to assure maximum heat transfer and to minimize corrosion. *To this should be added the need to protect cooling tower wood.* Since chlorination alone does not accomplish this purpose, the use of non-oxidizing biocides is required. The added cost for biocides should be charged partially to slime control, and partially to preventive maintenance to lower costs for tower repairs and assure longer tower life.

Biocides vary in the rapidity of their action and must be selected with a knowledge of the retention time of the system, as well as for compatibility with the corrosion control treatment and numerous other factors. Biocides must be specific for the organisms responsible for attack of cooling tower wood and must exhibit a broad spectrum of biological activity to properly control slime. Research on microbiological problems by Betz Laboratories has resulted in the development of effective and economical biocides. A study of your microbiological problem will entail no obligation. Why not contact a Betz Engineer today? Write, too, for a copy of Bulletin 605 which presents a comprehensive review on protection of cooling tower wood.

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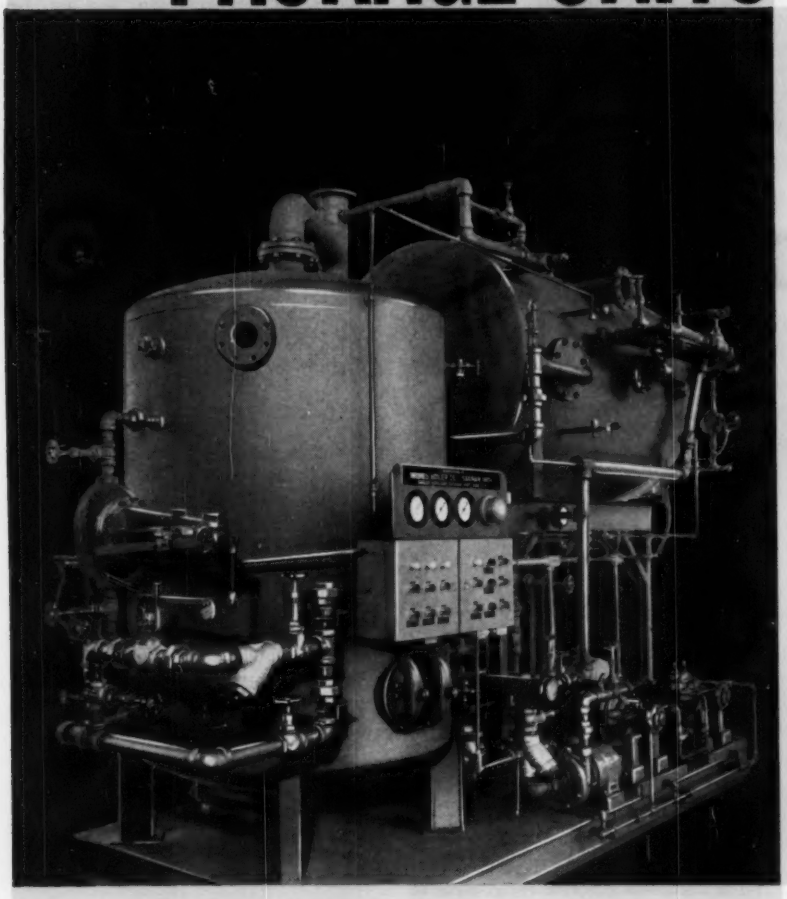

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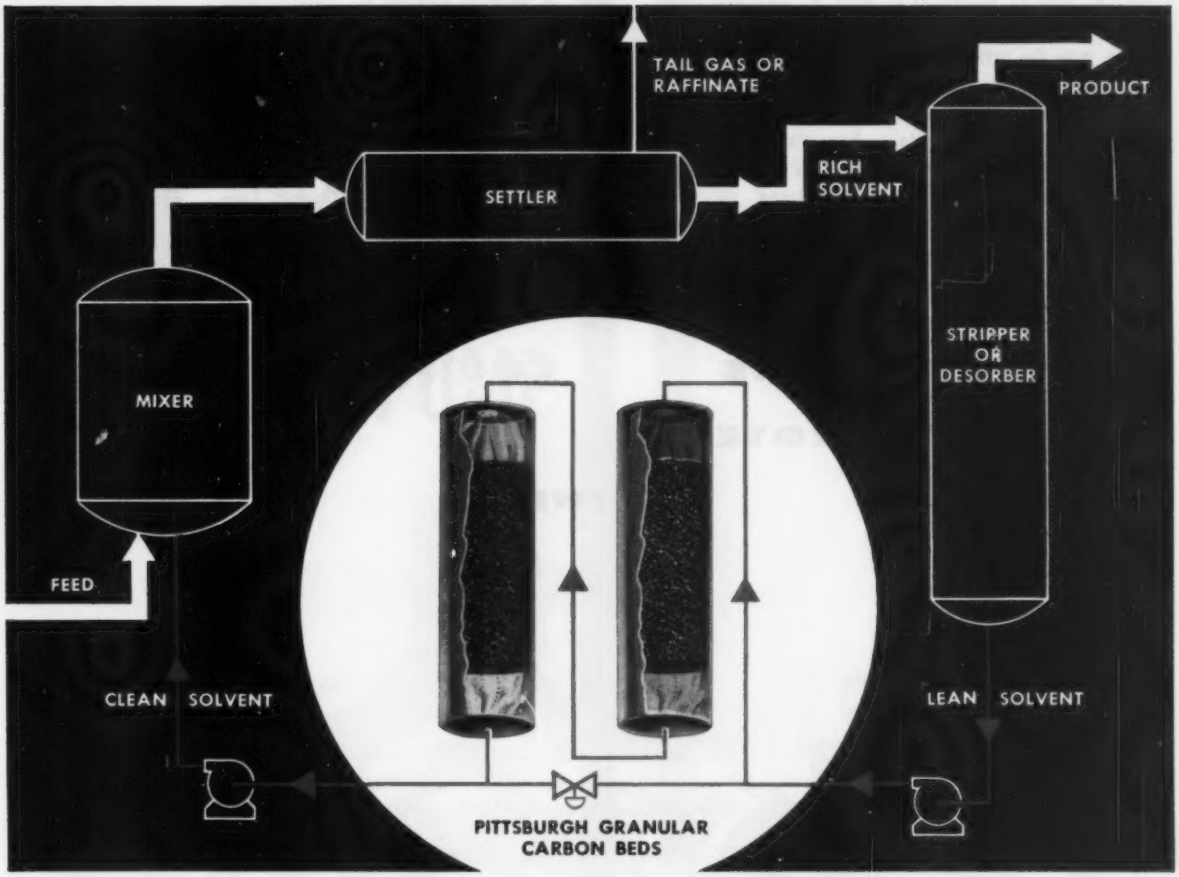

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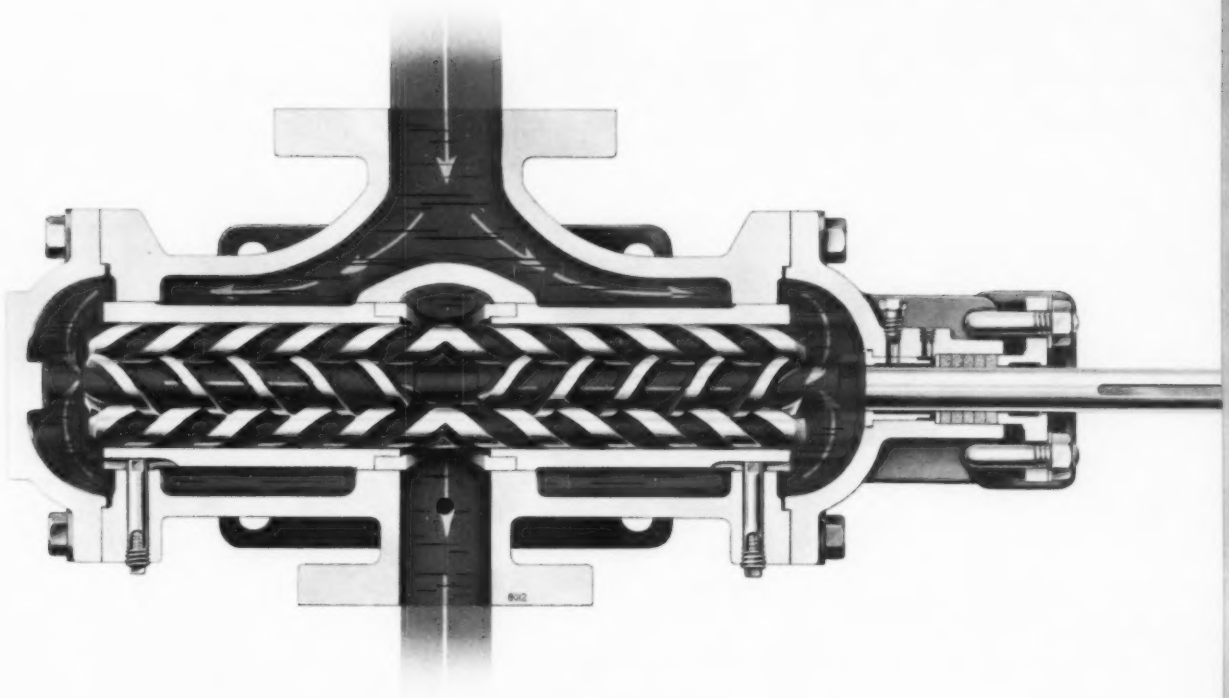

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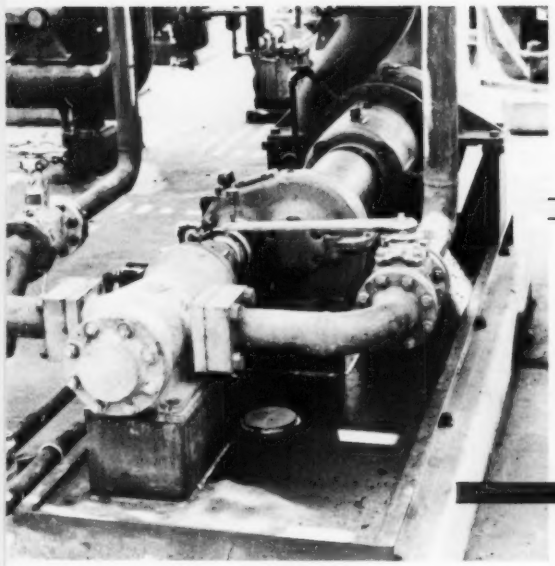
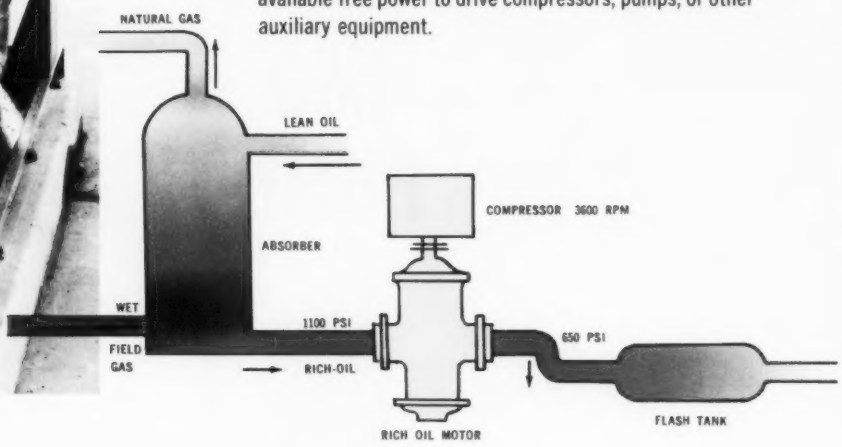
THE IMO AS A RICH OIL MOTOR



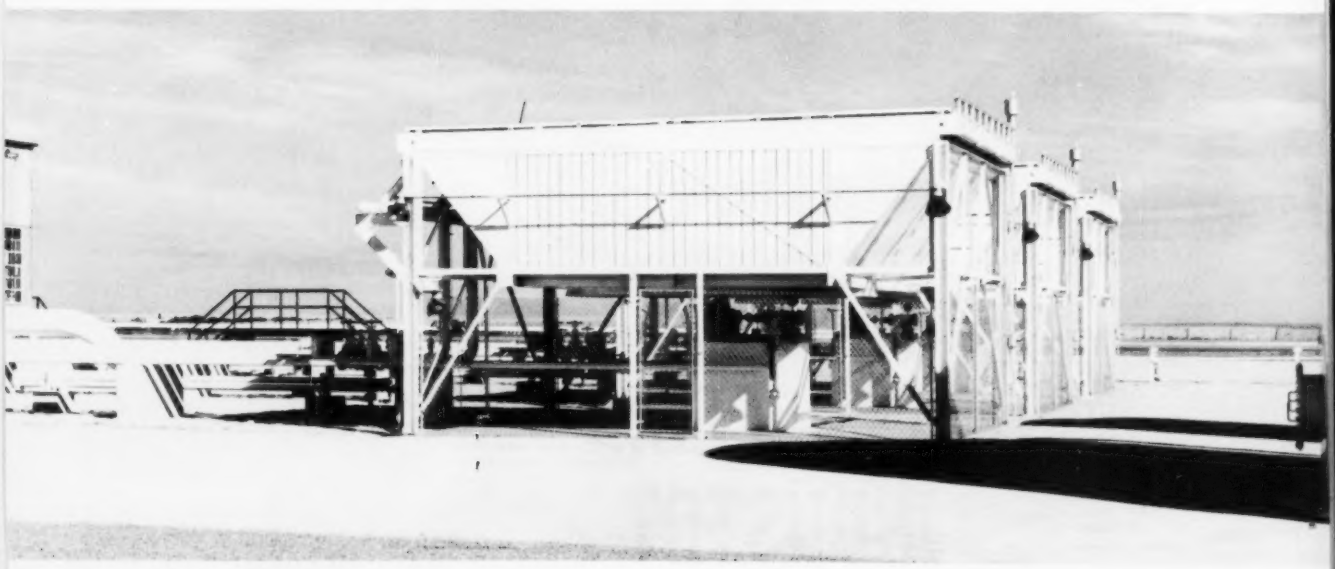
In the absorption process in a natural gasoline plant, the IMO utilizes the pressure drop between the absorbers and flash tank, which is normally accomplished through a reducing valve. The motor is capable of 500 psi differential, 900 gpm, 200 hp, and speeds to 3600 rpm. Use this available free power to drive compressors, pumps, or other auxiliary equipment.



THE IMO FOR HYDRAULIC FAN DRIVE

Solve power transmission problems, reduce costs and maintenance with a hydraulic fan drive system.

Look to IMO pumps and motors to cover the widest range of fan speeds and horsepowers requiring reliable trouble-free operation. Wide range of sizes permit extreme flexibility of system design.

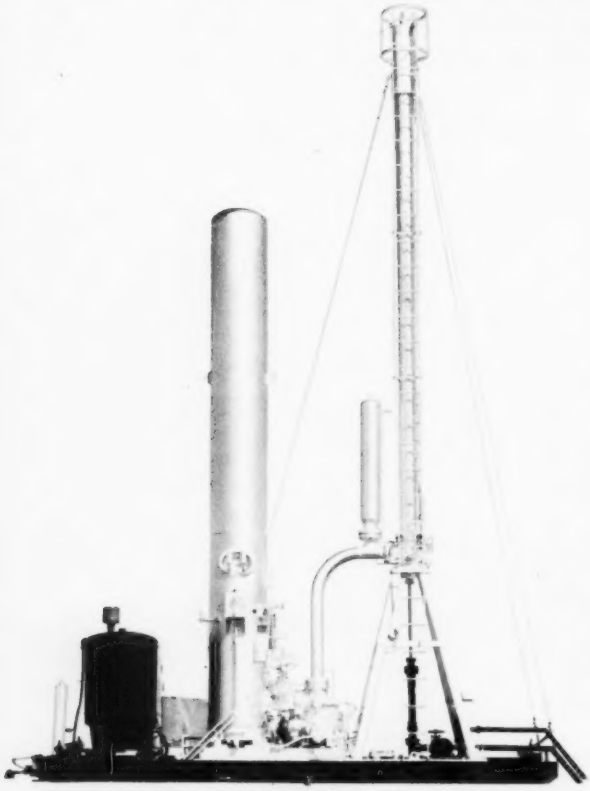


THE IMO AS A CRUDE OIL PUMP

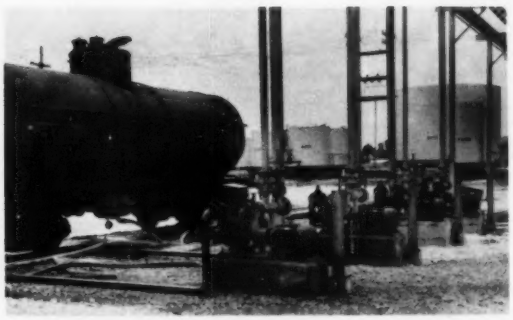
Eight IMO units are pumping crude in this Venezuelan Sun Oil Company installation on the first fully automatic flow station on Lake Maracaibo, Venezuela. Each pump is designed to deliver 12,500 b/d at 1000 psig at a direct drive speed of 1750 rpm.

Designed, fabricated and installed by J. Ray McDermott & Company, Inc. of New Orleans, La.

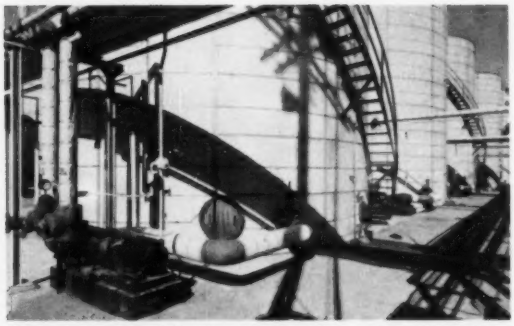
OTHER USES OF THE IMO PUMP IN THE PETROLEUM INDUSTRY



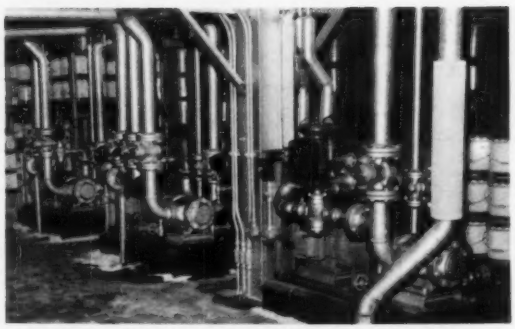
IMO actuates sucker rod in this hydraulic pumping jack. Pressures to 300 psi.



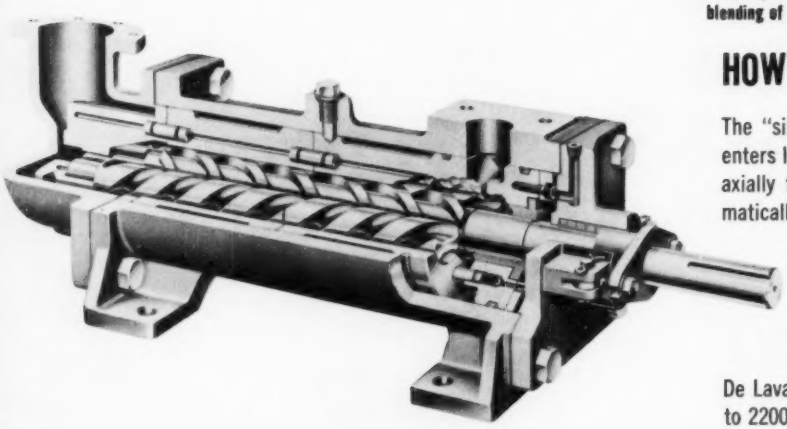
This tank car unloading application demonstrates the versatility of the IMO pump for practically any oil handling operation.



IMO pump for road oil blending. Handles 295 gpm of asphalt at 300 F. 950 SSU, and 50 psi.



Remotely controlled, the trouble-free IMO is used in packaging and blending of lube oil.



HOW THE IMO PUMP WORKS

The "single-end" IMO pump is illustrated at left. Fluid enters large inlet opening at outboard end and is moved axially to discharge without pulsation through mathematically calculated thread form.

The "double-end" design is illustrated on the front cover.

De Laval IMO pumps have only three rotating parts and do not require timing gears.

De Laval IMO pumps are capable of pressures from 10 to 2200 psi and capacities from 100 b/d to 67,000 b/d.

Illustrated are a few applications where the De Laval IMO pump has proved its reliability and efficiency. If you have a specific oil handling problem, a De Laval representative will be glad to discuss it with you.

DE LAVAL **STEAM TURBINE COMPANY** • **TRENTON 2, NEW JERSEY**

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FLAKE. Recently developed for users requiring a product that always flows freely. Dissolves rapidly. No extra cost!

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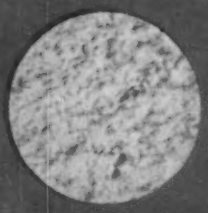

45-S GRANULAR. Similar to regular granular form, but preferable when greater resistance to caking in storage is desired.

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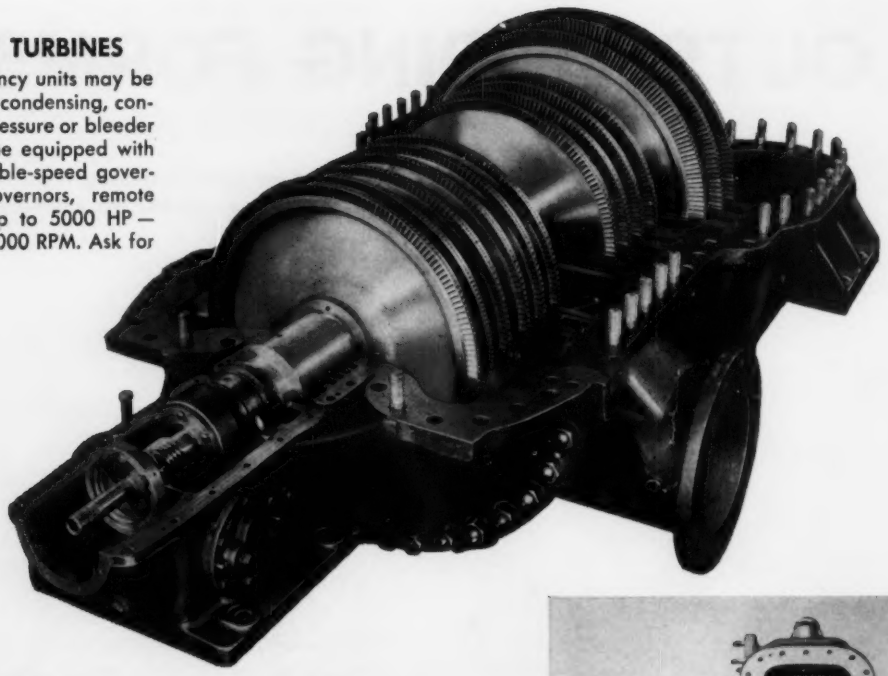
MULTI-STAGE TURBINES

These high-efficiency units may be designed for non-condensing, condensing, mixed pressure or bleeder operation. Can be equipped with constant or variable-speed governors, special governors, remote controls. Sizes up to 5000 HP — Speeds up to 10,000 RPM. Ask for Bulletin S-146.



There's a **Terry turbine** for every mechanical-drive requirement

The designs for Terry turbines are based on more than 50 years of successful experience in the manufacture of turbine drives *exclusively*. This specialization has resulted in Terry becoming one of *the leading producers* of mechanical-drive turbines in sizes up to 5,000 horsepower.

There are three basic reasons why Terry has been able to maintain this position of leadership: (1) a thorough knowledge of the requirements of mechanical-drive turbines, (2) a willingness to build "a little something extra" into each machine to assure trouble-free operation, and (3) an acknowledgement of the company's responsibility to stand behind the performance of every turbine sold.

These are also the reasons why you should consider a Terry turbine for your next mechanical drive. In the meantime, send for bulletins describing any of the types of machines illustrated.

THE TERRY STEAM TURBINE COMPANY
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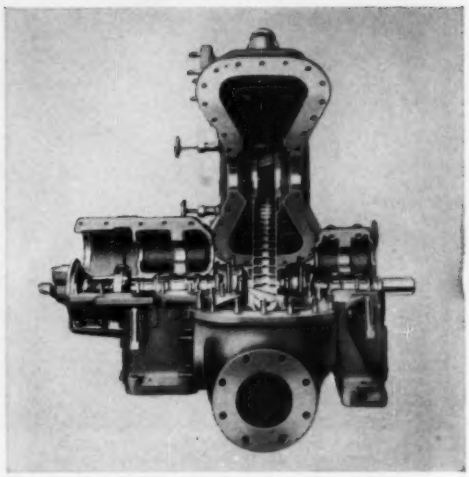
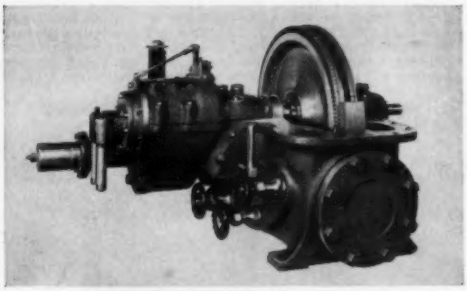
TERRY

TT-1209



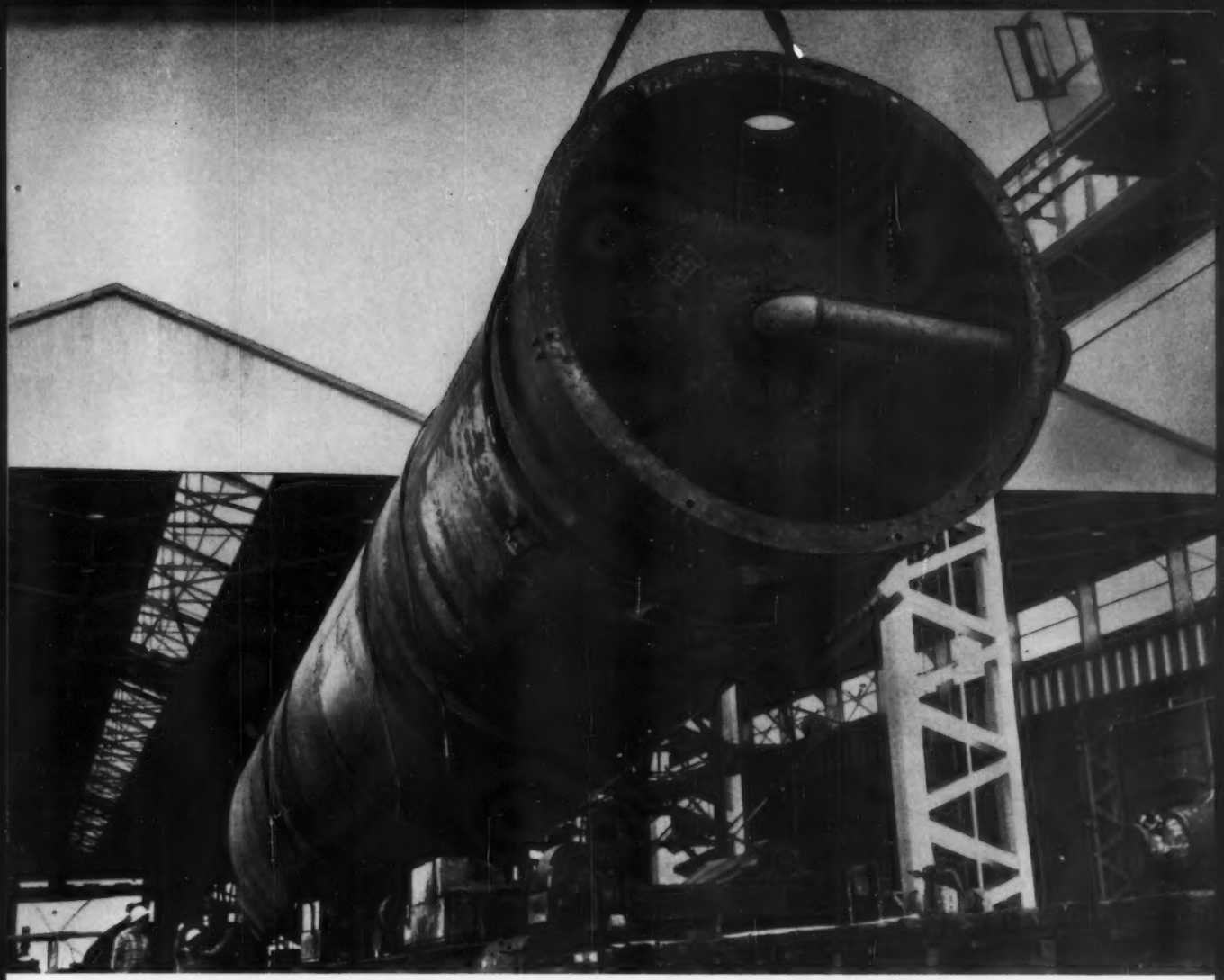
SOLID-WHEEL TURBINES

Famous for sure dependability and ease of inspection. Can be started cold — no preliminary warming required. Available in vertical designs depending on frame size. Capacities from 5 to 2,000 HP. Described in Bulletin S-116.



AXIAL-FLOW IMPULSE TURBINES

Built with one, two or three rows of high-grade stainless steel blading, these turbines combine efficiency with durability. Available in designs for moderate and high steam pressure. Bulletin S-143.



Designed by the Fluor Corporation, Ltd., for the Union Texas Natural Gas Corp.

It took a stork's big brother to deliver this 225-ton baby

High-capacity cranes were needed to handle this giant absorber unit (225 tons, 56′ long, 4″ shell), that required special attention and equipment all along the way. First, it was made of ASTM A212 Grade B Firebox Quality Plate, charpy impact-tested to 15 ft. lbs. @ —50°F. Then it was flame cut and roll formed. Its main stem was 100% radiographed, and its nozzle penetration was magnetic-particle inspected. The entire vessel was then stress relieved at 1150°F. for four hours. And finally, it was placed on special flat cars for delivery. ☐ This kind of job demands the complete, modern, high-capacity facilities that permit our Orange, Texas plate shop to handle all kinds of custom plate work. High-capacity cranes, mammoth car bottom furnaces, giant presses and bending rolls, the latest in welding equipment, and complete inspection facilities. This plus know-how and strategic location permit us to produce all kinds of plate work efficiently and economically. And anything we make, we can erect.

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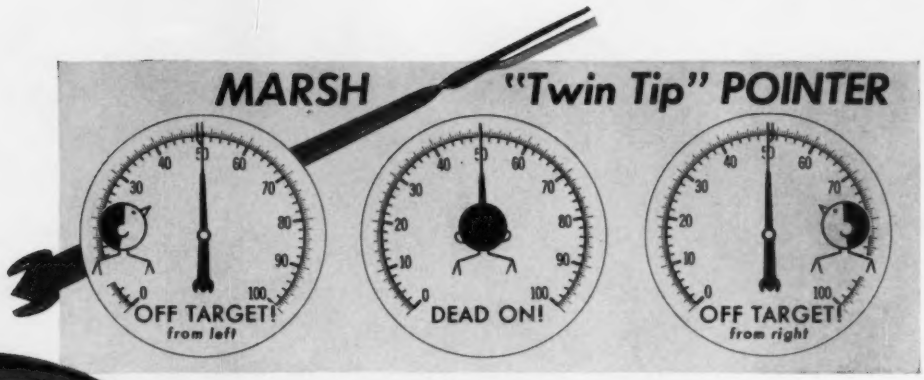


Now *reading accuracy* in keeping with *instrument accuracy*

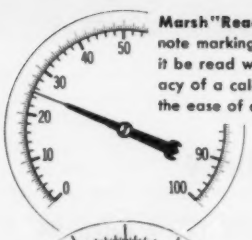
The development of the "Master-test" series brought industry pressure gauges of almost incredible precision ... gauges individually dead-weight tested ... gauges guaranteed accurate within ¼ of 1% of full scale reading.

But this extreme accuracy would have been meaningless unless the gauge could be *read accurately*—unless some means were provided for sighting the scale "dead on."

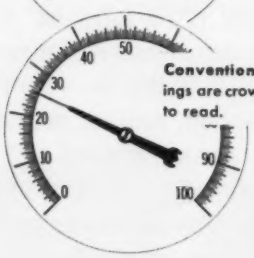
That was the reason for developing the "Twin-tip" pointer illustrated here. With the "Twin-tip" there is no excuse for wrong reading. If two tips are showing you're "off." If only one tip is showing you're dead on the target. It's as simple as that.

The Twin-tip has been declared a real innovation by all who have seen it. In addition to the "Twin-tip", "Master-test" gauges are also available with a Mirror Scale or with a "Non-parallax" scale which also provide reading accuracy in keeping with gauge accuracy. To make reading still easier all "Master-test" gauges have the "Read-easy" scale, illustrated opposite—another Marsh development.

"Master-test" gauges are made in sizes 4½", 6", 8". All standard ranges from 0-15 to 0-30,000 psi. Vacuum and compound types. Full range of case patterns.

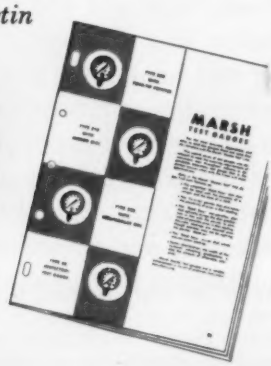


Marsh "Read-Easy" Dial note markings that permit it be read with the accuracy of a caliper, yet with the ease of a clock.



Conventional Dial markings are crowded in—hard to read.

Ask for this 20 page bulletin



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"THE STANDARD OF ACCURACY"

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Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta
Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

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Cut disconnect-reconnect time by as much as 50%

The FALK Spacer Coupling is specially designed for quick installation or removal *without disturbing the driving or driven unit.* This feature can save you up to 50% in disconnect-reconnect time when critical equipment—a process pump, for example—needs repair or replacement.

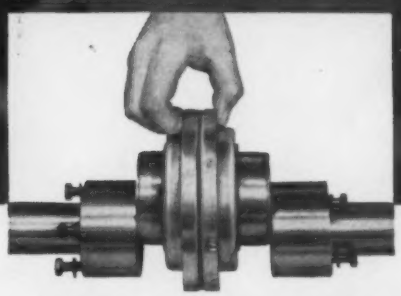
Here's another saving: with the FALK Spacer Coupling, you can quickly realign shafts *without the usual loss of operating temperature!*

And still another: you can remove or reinstall the FALK Spacer as a unit *without draining the lubricant.*

Because of its exclusive grid-groove Steelflex design, the FALK Spacer can accommodate residual misalignment—parallel, angular, or (most important) *both.* Also, it provides torsional resiliency that cushions shock and vibration. Thus it saves wear-and-tear on your connected equipment.

To prove these claims and enjoy these savings, install a FALK Spacer on one application—and see for yourself. Consult your FALK Representative or Authorized Distributor.

THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN
MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS
Representatives and Distributors in many principal cities.

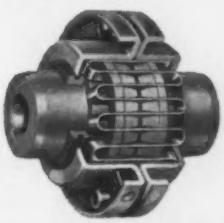


EASY AND QUICK TO INSTALL, DISCONNECT OR RECONNECT

First, mount shaft hubs to allow proper distance between hubs; then, align driving and driven units.

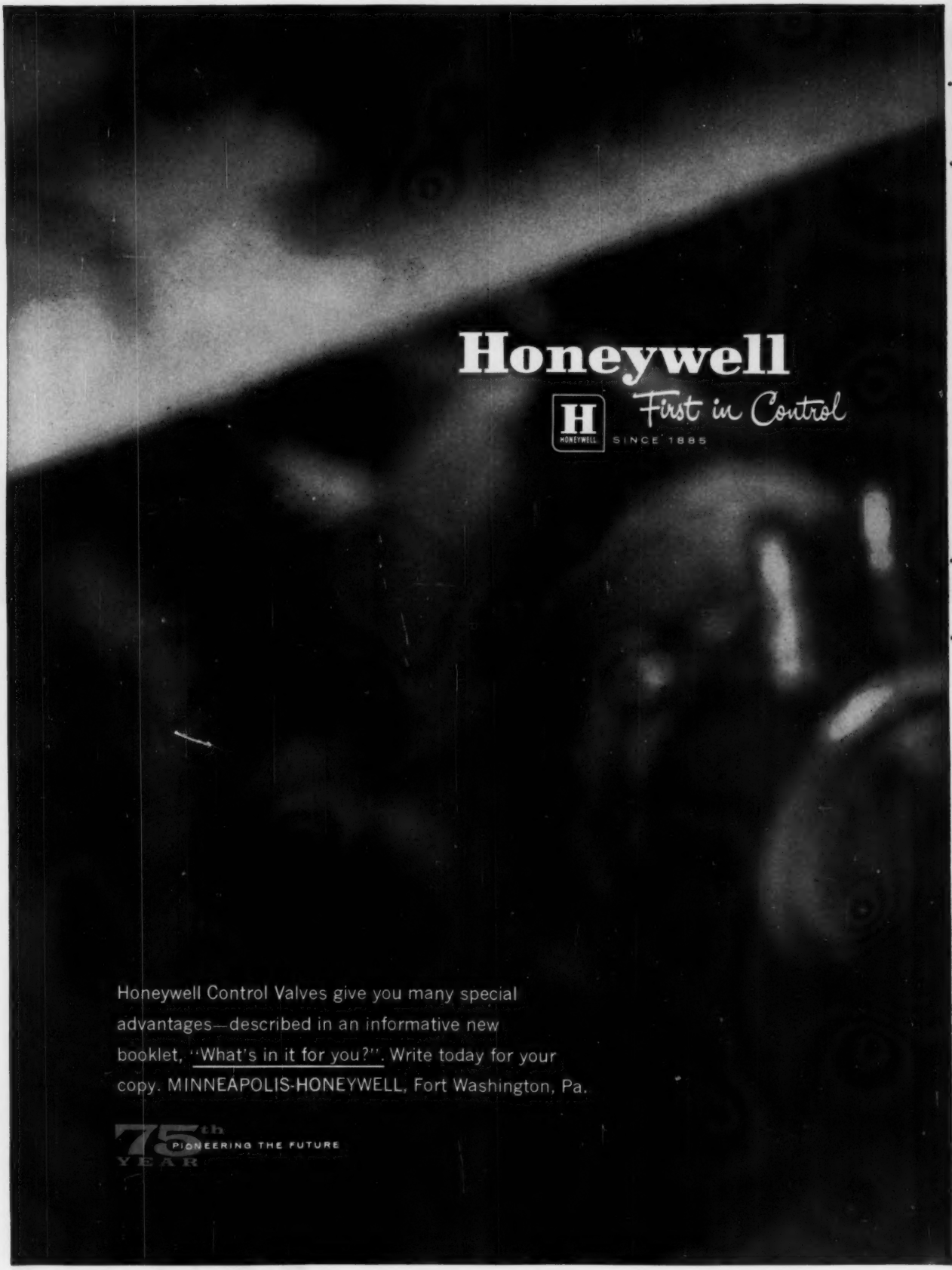
Second, compress Spacer to fit space between hubs and tighten cap screws to pull spacer hubs into the registered fit.

To disconnect, reverse the second step. No draining of lubricant necessary.



The heart of the FALK Spacer ...the basic Type F Steelflex
Write for Service Manual 4838

FALK
...a good name in industry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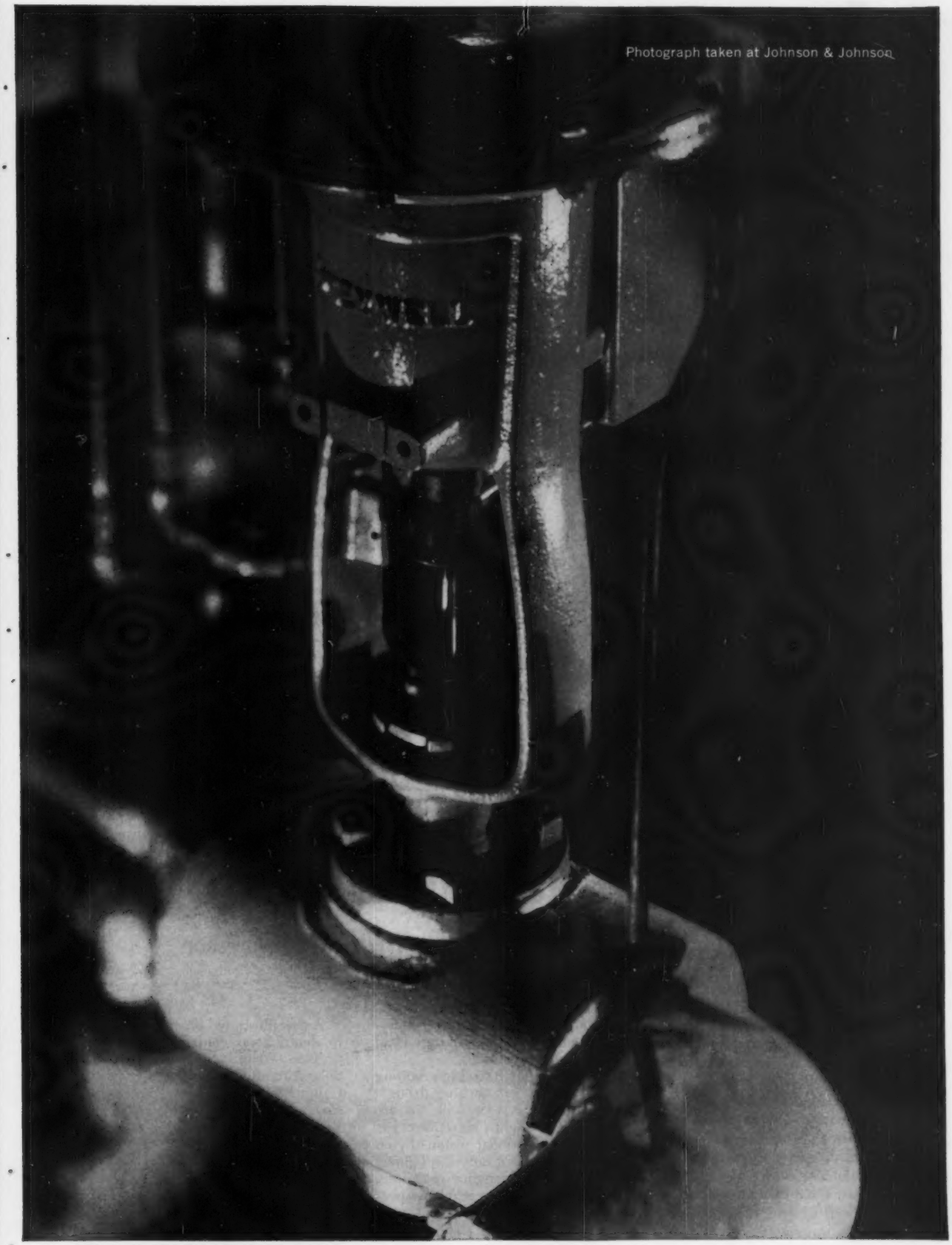
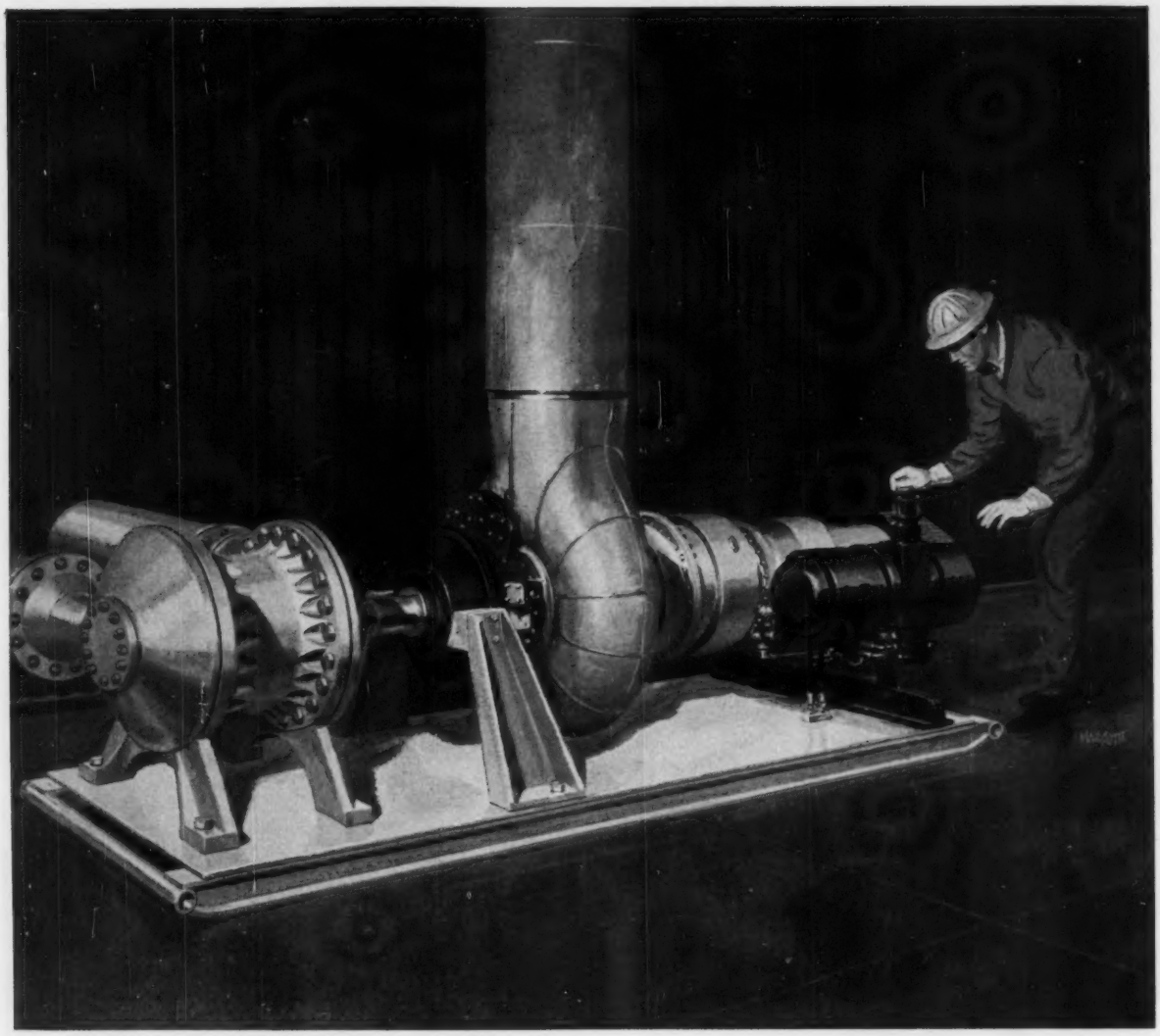


For more data on advertised products, use Readers' Service Cards, last page.



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Solar industrial gas turbine-driven centrifugal compressor offers advantages found in no other type

SOLAR'S LIGHTWEIGHT centrifugal compressors incorporate unique new features for applications in the low-volume range. They operate in a range of flows and pressures new to centrifugal equipment. Interchangeable compressor wheels and other parts permit quick, low-cost field changes to accommodate new flow and pressure requirements. Ideal for main pipeline stations as well as field use, they can be started or shut down in seconds—even by remote control—and are ideal for unattended operation.

Designed to match the high rotating speeds of Solar gas turbine drivers, Solar's new compressor packages are small and lightweight (a fraction of the weight of conventional piston-driven units). They require only the lightest foundations. Maintenance is simple. Easy portability allows periodic inspection at a central shop.

A new illustrated brochure describes in detail Solar centrifugal gas compressors. Write for it to Dept. H-112, Solar Aircraft Company, San Diego 12, California.

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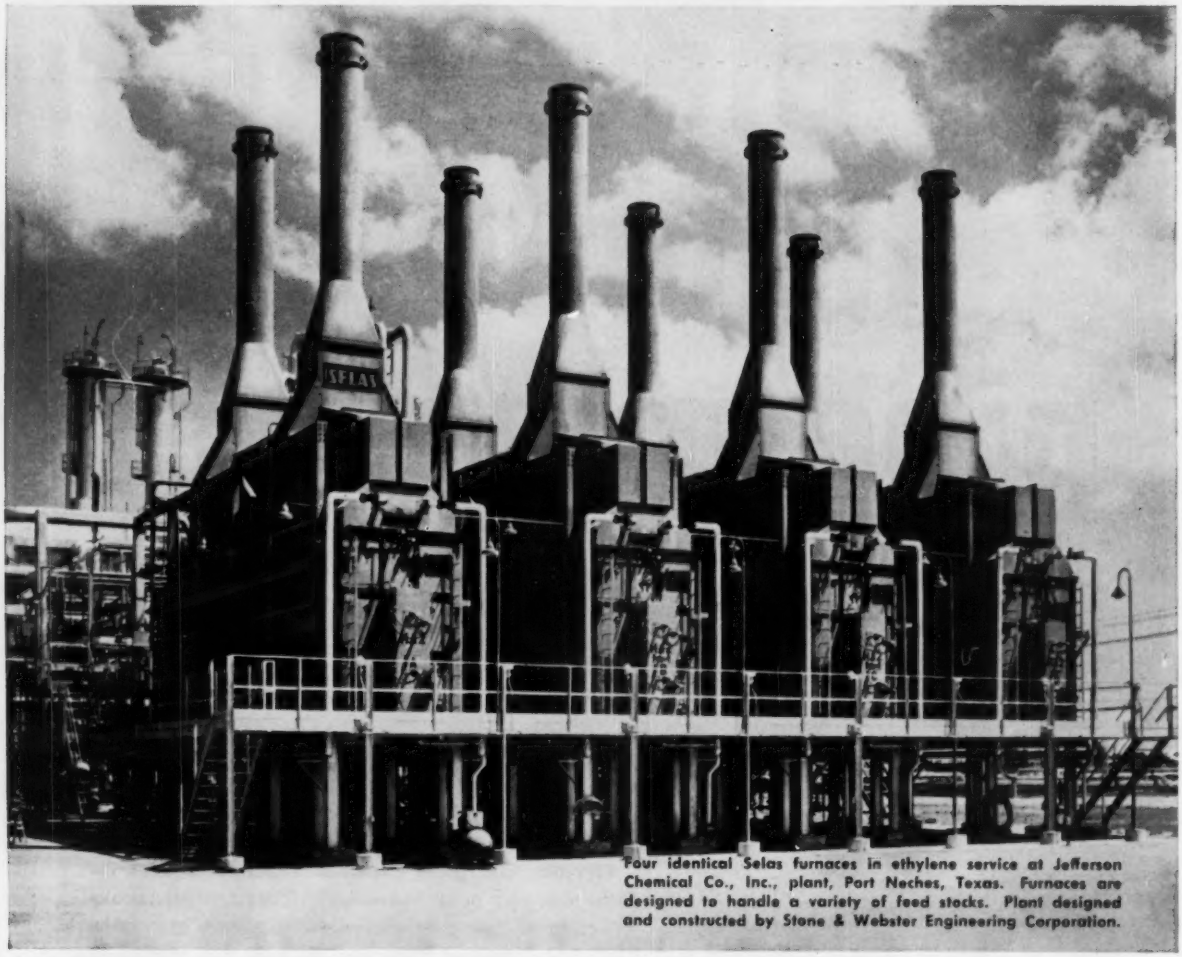
relies on Selas Gradiation® Heating for
ZONE CONTROL • PRECISENESS • UNIFORMITY



Four identical Selas furnaces in ethylene service at Jefferson Chemical Co., Inc., plant, Port Neches, Texas. Furnaces are designed to handle a variety of feed stocks. Plant designed and constructed by Stone & Webster Engineering Corporation.

In ethylene production, the following inherent features of Gradiation heating have been translated, at Jefferson Chemical Co., into . . . *Longer on-stream periods . . . fixed amount of production with less feed stock . . . greater depth of cracking when limited by actual metal temperatures:*

- Zone Control . . . Duradiant® burners can be adjusted to desired heat pattern, in horizontal rows, to produce optimum reactions in pyrolysis.
- Uniformity of heating . . . even-heat distribution along and around tubes, increases tube life by eliminating hot spots, minimizing coke formation.
- Preciseness of heating . . . complete combustion within Duradiant burner cup permits placing burners close to tubes . . . achieving fast heat-up and instantaneous response to controller demand.
- Versatility . . . Gradiation heaters can handle a variety of feedstocks, interchangeably, under optimum conditions.

May we arrange for a Selas field engineer to discuss your heat processing needs with you? For this service . . . without cost or obligation to you . . . or for a copy of Bulletin "Gradiation Heating for Petroleum and Chemical Processing," write to Mr. M. Kitzen, chief process engineer, Fluid Processing Div., Selas Corporation of America, 75 Dreshertown Road, Dresher, Pa.

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Heat and Fluid Processing Engineers

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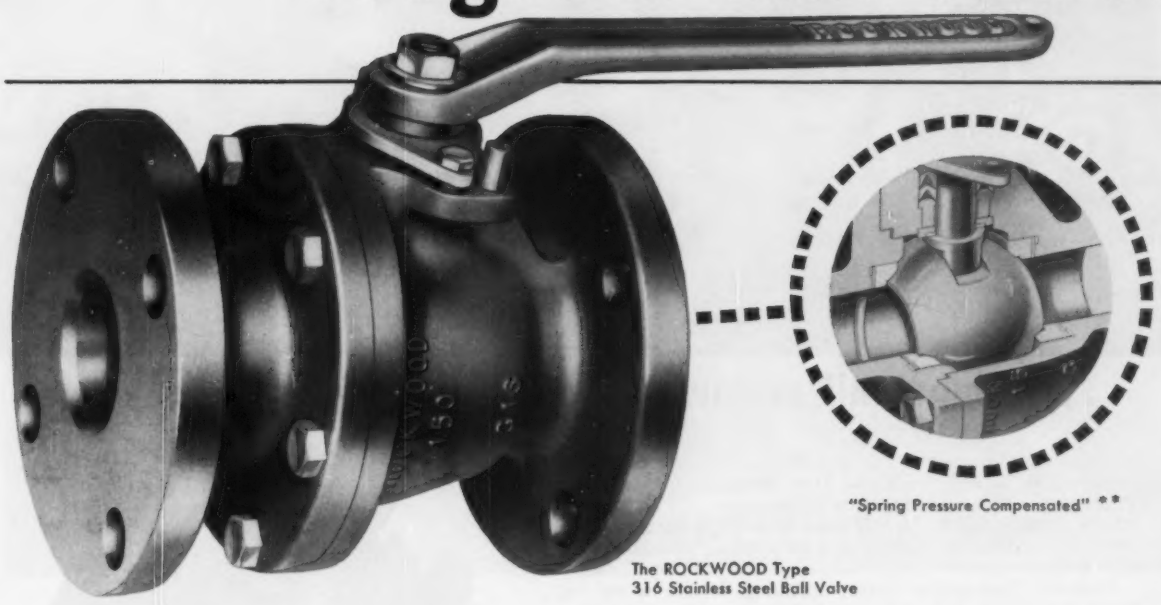
NEW...

Today's "Tightest" and Toughest Ball Valve!



"Spring Pressure Compensated" **

The ROCKWOOD Type
316 Stainless Steel Ball Valve

Here's the new 316 stainless steel ball valve that not only gives you maximum corrosion resistance, but also *positive* assurance of leakproof service!

It's Tightest because exclusive spring rings back up its twin Teflon* seats . . . *automatically* compensate for pressure variations, wear, cold-flow deformation and temperature effects. With flow in either direction . . . under vacuum or 600 psi . . . seats always hug the ball.

It's Toughest because it's made with integrally cast flanges or screw ends. They *stay* leakproof even under constant vibration.

You get all the other ROCKWOOD features, too: smooth, full round flow; easy ¼ turn opening and closing; dead tight sealing without lubrication; and many more. For use at temperatures from −65°F to 350°F, the Type 316 can be easily modified for cryogenics applications. Always tight in vacuum service, too. Handles air, alcohols, fuel and inert gases, water glass and many other fluids. For service up to 600 psi. 4 models available. Sizes ⅜" through 2". Send coupon for complete details. Tested and listed by Underwriters' Laboratories, Inc.

*DuPont Reg. T.M. Teflon seals include seats and adjustable chevron stem packing. Also available with nylon or synthetic rubber seals.

**Patent Pending

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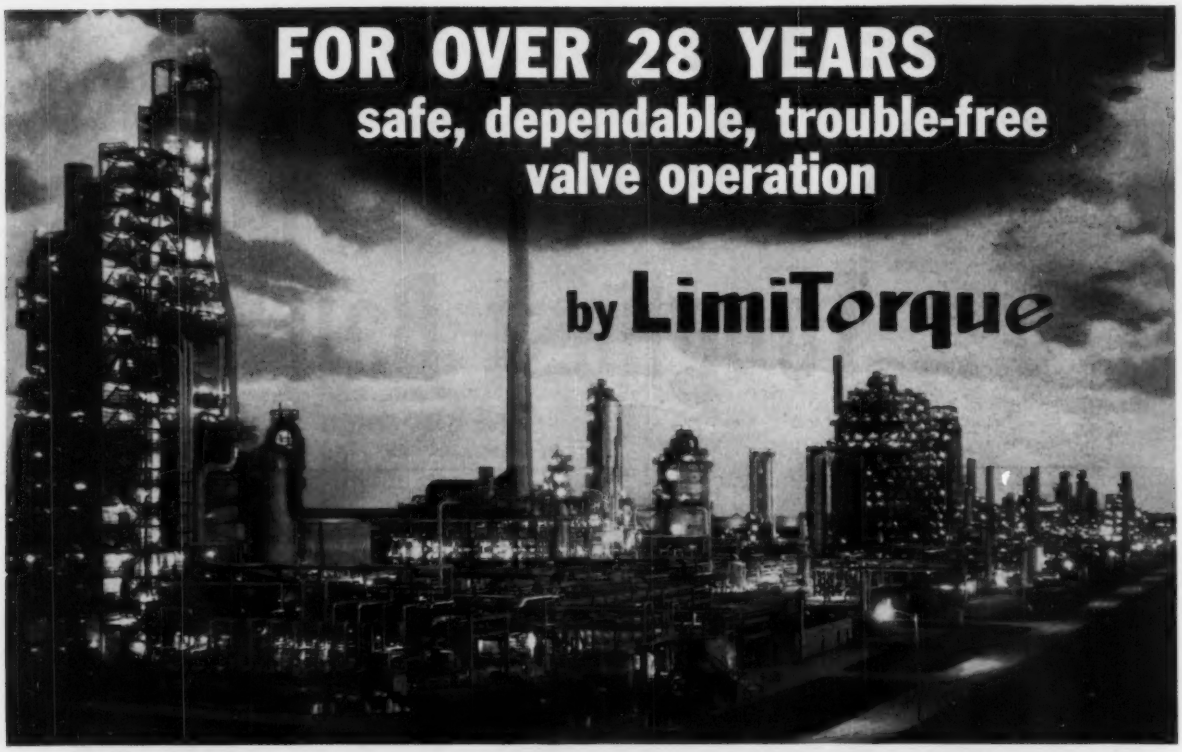


. . . in most all major refineries throughout the world

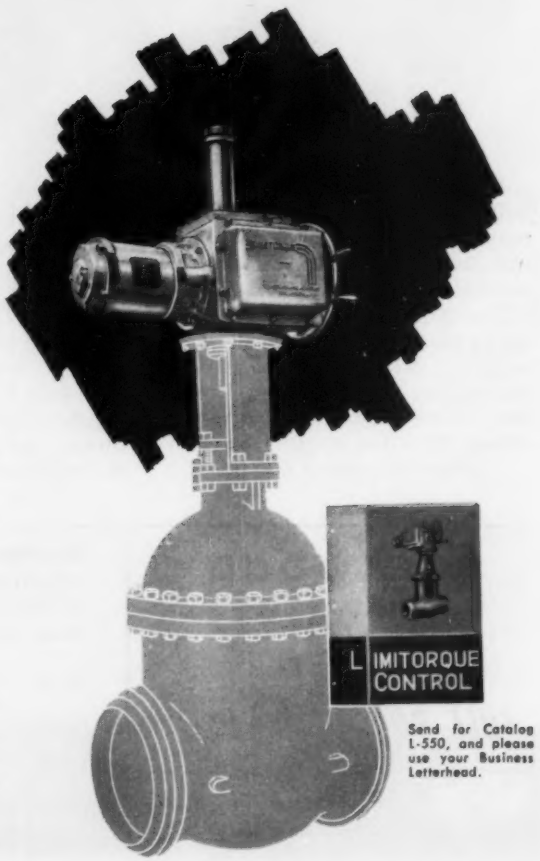
Round the clock, dependable service has been performed by LimiTorque in Refineries and High Pressure Oil and Gas Transmission Lines for a period of 28 years . . . in Canada, Alaska, Venezuela, the Middle East, Sumatra, Sahara, Mexico; all over Continental Europe, and of course, throughout the United States.

Faithful, Dependable Valve Operating Service is the big factor that has made LimiTorque famous—and it is the reason why LimiTorque is the most widely used Valve Operator in the World.

LimiTorque is available in numerous types and variations . . . all "custom built" to do the exact job you require . . . Speeds of operation can be varied over a wide range, even to the provision of two speeds in one direction of travel—and Electrical Control Equipment, such as reversing starters, relays, transformers, etc. may be included, to make a complete operating "package"

Regardless of whether valves are to be automatically operated indoors or outdoors—in sub-zero or elevated temperatures —under snowy, rainy, dusty, or bad fume conditions, there's an exact type and size of LimiTorque to meet your valve operating requirements.

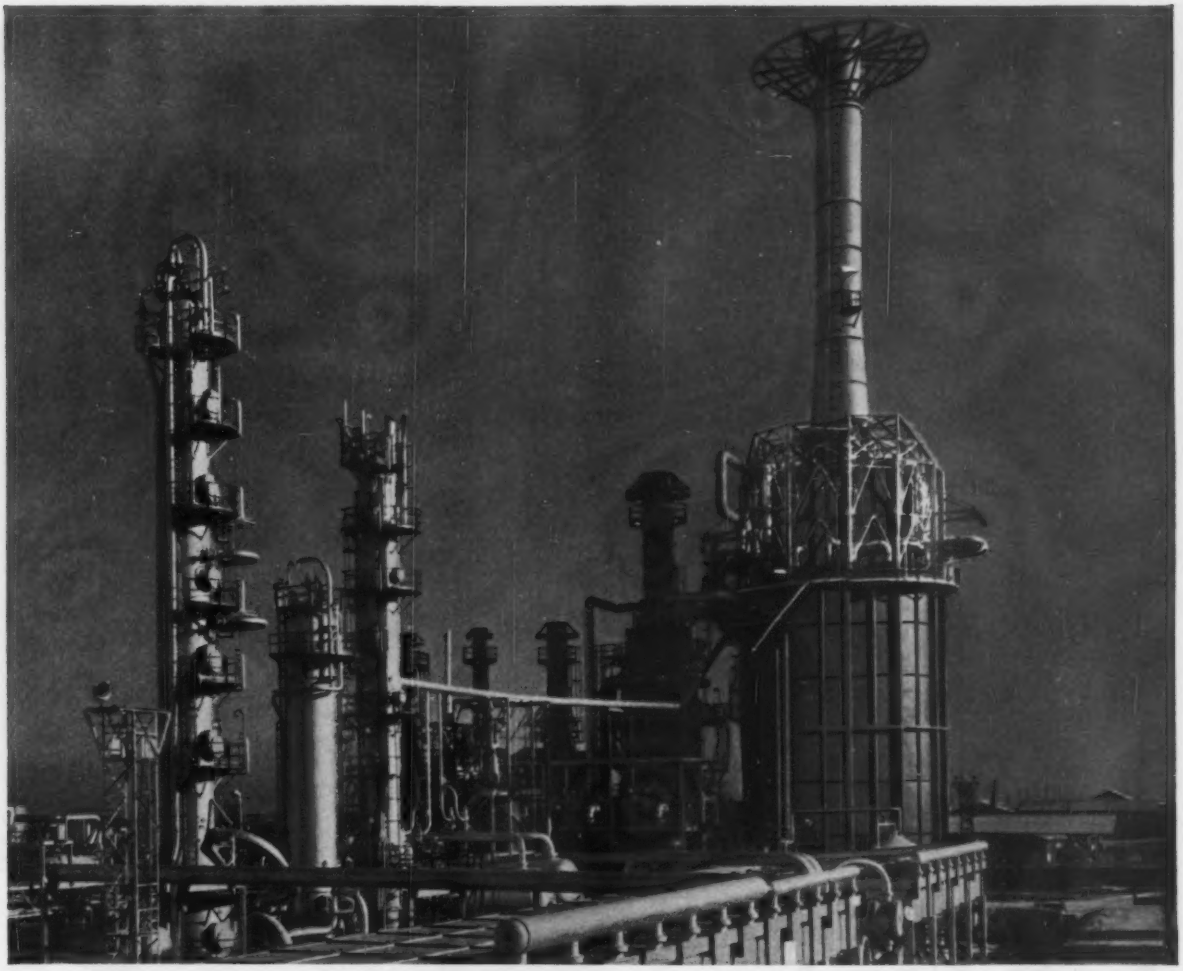
Consult your Valve Manufacturer, or your nearest LimiTorque Sales Engineering Office . . . and remember, there are 28 years of continuous designing and manufacturing experience back of LimiTorque.



THERE IS NO SUBSTITUTE FOR —
LimiTorque®

PHILADELPHIA GEAR CORPORATION
KING OF PRUSSIA (SUBURBAN PHILADELPHIA), PA.
OFFICES IN ALL PRINCIPAL CITIES
INDUSTRIAL GEARS AND
SPEED REDUCERS
LIMITORQUE VALVE CONTROLS
FLUID AGITATORS
FLEXIBLE COUPLINGS
Limitorque Corporation • King of Prussia, Penna.

Send for Catalog L-550, and please use your Business Letterhead.



176 million Btu/hr from a single vertical heater

The Foster Wheeler direct-fired heater above is the largest cylindrical vertical heater in the world. It was designed and built for the Powerformer section of a major French refinery.

This unusual unit features a 41-foot diameter fire box and a separate horizontal convection section. It has an overall height of 200 feet and is designed for high thermal efficiency with ease of operation. Foster Wheeler coordinated U. S. engineering and foreign procurement to assure minimum cost.

Designing efficient direct-fired heaters ranging in size from giants like this one—to midget-sized 100,000 Btu/hr units for special applications—has been a continuing FW function for over 40 years. You will find FW's fired heater and process experience invaluable to the solution of your heating problems.

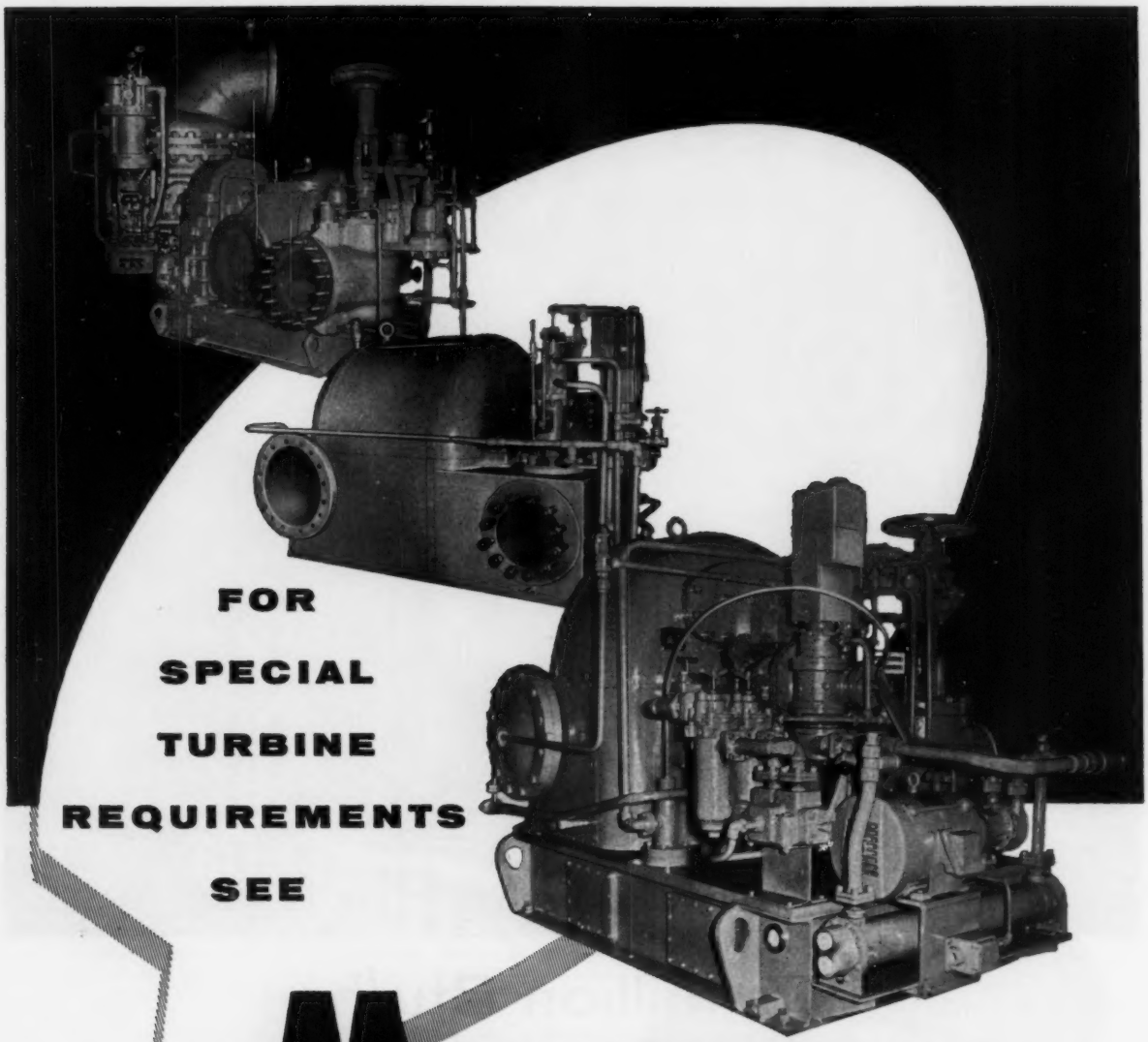
Consult with Foster Wheeler before you specify. Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.

Heat Engineered products, plants and processes . . . for the world's industrial progress.

FOSTER WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.

For more data on advertised products, use Readers' Service Cards, last page.



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TURBINES

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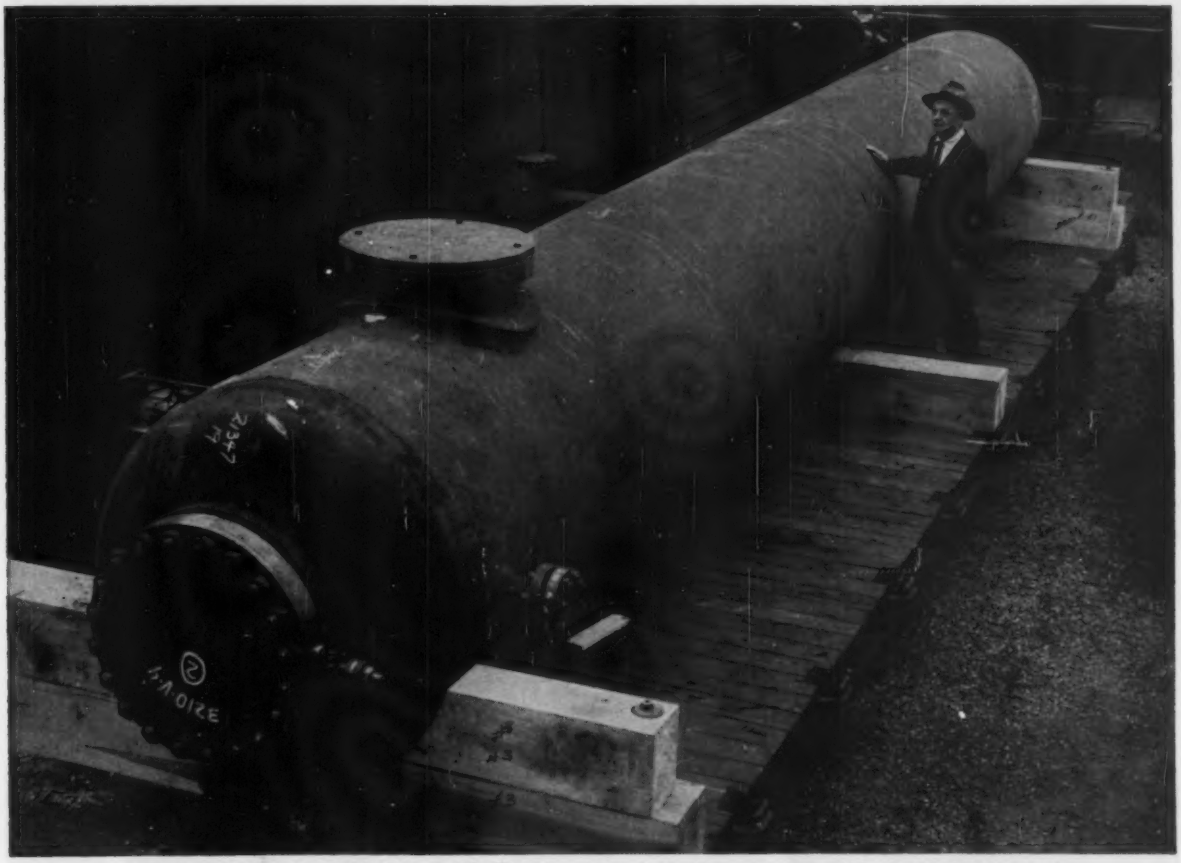
- High Back Pressures
- High Speeds
- Variable Speed Ranges
- Precise Control
- Multi-Valve Designs
- Double End Gear Drives
- Vertical Shaft Turbines

Our nearest representative will help you solve your turbine requirements. His name gladly sent on request.

MURRAY IRON WORKS COMPANY • BURLINGTON, IOWA

Builders of Steam Power Equipment for Nearly a Century



NEWPORT NEWS BUILT two 39'-7" horizontal gas scrubbers, such as this, for J. F. Pritchard & Co. They were made of ASTM-A212 Grade B fire box steel, with structural mesh steel interiors.

Gas scrubber made of 2⅞" steel

Newport News builds almost any type of pressure vessel and other heavy process equipment

Here is one of two horizontal gas scrubbers recently built for an operating pressure of 1800 psi at 300°F.

Newport News made both vessels from fire box steel, 2⅞ inches in thickness. We formed and automatically welded this steel into sections having a diameter of only 4 feet.

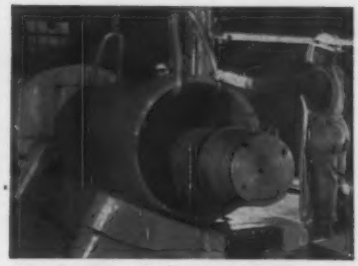
Rolling thick steel to this small diameter...no easy accomplishment, as you probably know . . . demonstrates the sort of jobs Newport News takes in stride.

Almost any type of heavy processing equipment is readily constructed by Newport News in a 225 acre plant comprising huge, fully equipped fabricating and machine shops, foundries, forge and die shops, heat treating and allied equipment as well as complete test facilities.

Newport News shop erection of fabricated units helps to speed assembly at your plant site.

Get a bid from Newport News on your present or future projects. Get the benefit of specialized production techniques. Look over the many ways in which Newport News can help you . . . write for "Facilities and Products", a very interesting booklet. It's yours for the asking.

ENGINEERS Desirable positions available at Newport News for Designers and Engineers in many categories. Address inquiries to Employment Manager.



ROLLING 2⅞" STEEL for gas scrubbers. The steel, in a hot condition, was formed on the heavy bending equipment shown here. It will cold roll mild steel up to 3 inches thick, and will hot roll any grade of steel up to a thickness of 5 inches.

Newport News Shipbuilding and Dry Dock Company
Newport News, Virginia

For more data on advertised products, use Readers' Service Cards, last page.

ORBIT ADDS VALVES TO INDUSTRIAL LINE

ORBIT CAST STEEL VALVES FOR HYDROGEN AND SIMILAR INDUSTRIAL GASES

As an addition to our line of valves handling hydrogen, similar industrial gases, and hydrocarbons, Orbit Cast Steel Valves have proven ideal for compressor, manifold, off-site and block valve installations.

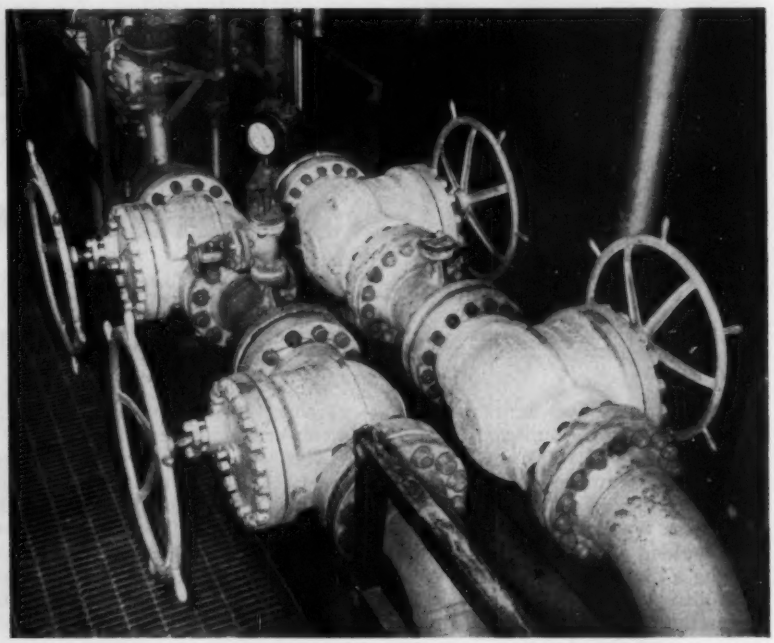
Orbit Cast Steel Carbon Trimmed Valves are particularly well suited to all the operating problems attendant to safest handling of industrial gases. These valves employ Orbit's friction-free seating principle already well known to users of our Forged Steel line of Industrial Valves.

All principal parts of Orbit Cast Steel Valves are made of steel castings and steel drop forgings, with bonnet bolted to body. A stem locking device permits valve to be locked open or closed. 2½ to 3 turns opens or closes valve.

SIZES: 5", 6", 8" & 10" *Series 300 and 400 Flanges
5", 6" & 8" *Series 600 Flanges
5" & 6" *Series 900 Flanges

Above sizes except 10" available in Screwed Ends.
*End to End Dimensions are Special.

ORBIT CAST STEEL VALVES INSTALLED ON HYDROGEN GAS COMPRESSOR MANIFOLDS IN A LARGE OHIO REFINERY.



ORBIT VALVES ®

Available through your favorite supply house. Or, write Orbit today for complete information and specifications.

ORBIT VALVE COMPANY

P. O. BOX 699, TULSA, OKLAHOMA
PHONE LUTHER 4-4761, TWX TU 925

SEAMLESS

- Long radius or short—the finest ells ever made . . . hot coined for dimensional accuracy from end to end
- Forged at controlled heat for superior metallurgical quality
- Specially machined ends for quickest fit-up and welding
- Ells, tees, returns—all types of fittings—available in seamless through 24"
- Produced by newest, most modern equipment, combined with latest technology in forging, sizing, heat-treating and machining

Now... Midwest makes BOTH!

WELDED

Formed from plate and welded—fully reinforced . . . same high quality as always

Especially suited for Long Tangent bonus elbows, reducing ells, and special fittings of unusual shapes

Stocked in carbon steel, wrot iron, chrome-moly . . . available in Hi-Yield and all other weldable metals

Wall thicknesses up to 4"—or more

Delivery from stock—with or without Long Tangents—in all sizes through 36"; to order, through 48"

The world's most complete line of welding fittings...for maximum flexibility in piping design

SOLD THROUGH STOCKING DISTRIBUTORS FROM COAST TO COAST

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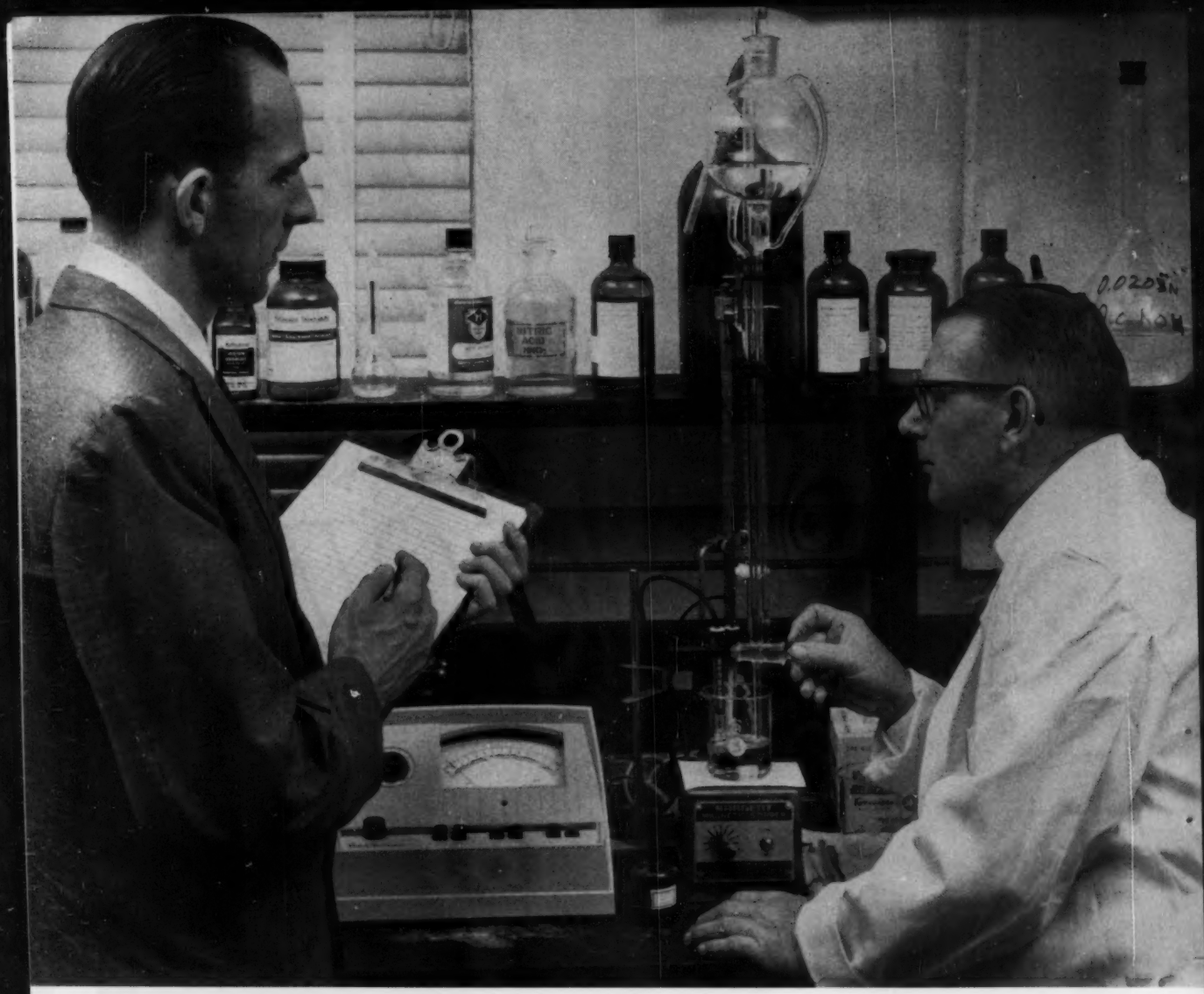

Jefferson Gas Processing Specialist takes your problem to the laboratory

Specific analyses of amine solutions are often needed to pinpoint gas sweetening difficulties. After studying your problem, Jefferson's Gas Processing Specialist will know which analyses to recommend. Frequently, he will request samples to be sent to Jefferson's Austin Laboratories, where analytical equipment and specialized experience, not ordinarily found in plant laboratories, are available.

Let's say your sample is a lean diethanolamine solution and he needs to know such factors as: DEA from alkalinity before and after ion exchange; DEA calculated from Kjeldahl test for total nitrogen; analysis of other nitrogenous materials such as ammonia, thiocyanate, etc.; determination of heat stable salts present; viscosity; alkali metals; iron and iron capacity. Jefferson's Gas Processing Specialist requests and coordinates these tests. His detailed interpretations of the results are correlated with information on your specific operating conditions. Successful remedies to your problem most likely follow.

Prompt, dependable technical services plus ethanolamines and glycols in any quantity . . . they're yours from Jefferson Chemical Company, Inc., 1121 Walker Avenue, P. O. Box 303, Houston 1, Texas.

Ethylene and Propylene Oxides, Glycols, Dichlorides, Carbonates
SURFONIC® Surface-Active Agents • Ethanolamines • Morpholine
N-Alkyl Morpholines • Polyethylene and Polypropylene Glycols
Piperazine • Piperazine Salts • Nonyl Phenol • Caustic Soda

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JEFFERSON CHEMICALS

004

Hagan PowrMag Analog Computer Control

simple as

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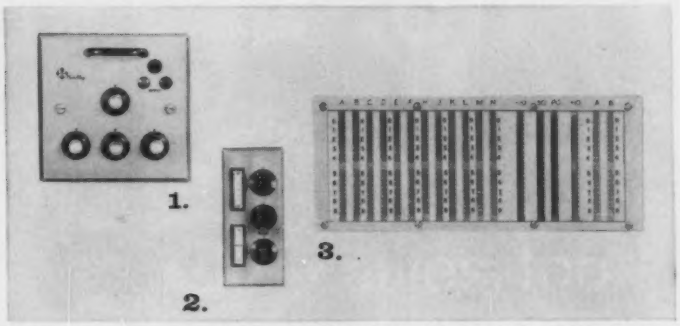

PowrMag systems embody the highest degree of flexibility. Simple, efficient electrical design utilizing long-lived and trouble-free solid state components, and rugged mechanical construction suit the system for a variety of industrial process control applications.

1. *Magnetic Control Unit*

This magnetic amplifier, operating on 1-9v DC, may be used individually, as a single 2 or 3 mode controller, or as one element in a large system. Each control unit may be removed from the front of the panel for easy interchangeability. The basic unit is easily converted to other modes by the addition of interchangeable, plug-in circuits for *all* common control operations. Inventory is reduced to the one basic unit. Unaffected by shock or vibration, PowrMag has no moisture, dirt, leakage or freezeup problems—3.5 watts of unregulated 110v, 60 cycle AC. Size—5¼" x 5¼".

2. *Remote Control Station*

These stations provide for remotely established set points and required manual control operations. Full station may contain two single or ganged potentiometers, one switch and two meters. Size—2¼" x 5¼". Half stations available with set point, bias or ratio dial and output signal indicator. Size—2¼" x 3⅛". Each station uses 12-wire, color-coded electric cable with MS-type connector. Front mounting and removal make it ideal for the compact console installations required for centralized control.

3. *Patchboard*

Interconnecting the system in any desired manner, via color-coded electrical cable, the patchboard requires no solder connections or terminal boards—all connections are made by special taper pins. Each connection is identified by an alphanumeric combination. Numbers, run vertically, identify the components in the system, such as magnetic amplifiers, controllers, transducers, etc. Letters, run horizontally, identify the connectors leading into the patchboard. DC control power bus is in the center section—no AC voltages are used in the patchboard.

Easy front access permits simple changing of operations. Additional loops or components are readily added to the system.

A letter or phone call will bring you complete information on the PowrMag system. **Ask for Bulletin MSP-163.**

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PENNSYLVANIA

HAGAN DIVISIONS: CALGON CO. — HALL LABORATORIES — BRUNER CORP.

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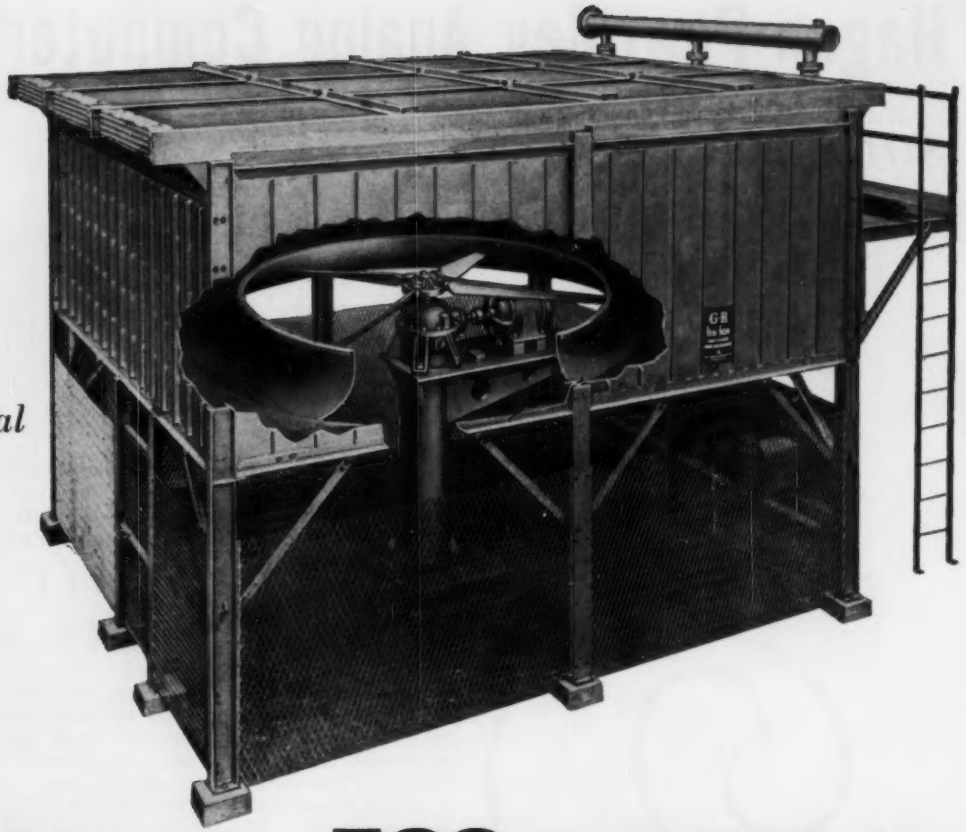
Designed for the Petrochemical Industry



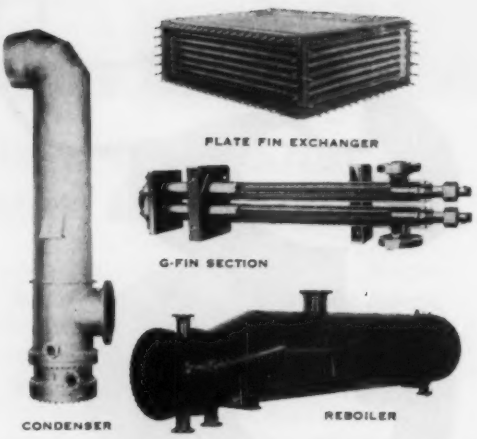
Proved in over 500 installations

Griscom-Russell fin-fans, by eliminating the cost of water, pumps, piping, valves, water treatment and maintenance, are the economical heat exchangers for many petrochemical cooling and condensing services.

G-R **fin-fans** are designed of the highest quality components to fit your special application. The transfer area is made of G-R's strong, helically finned tubing for highest efficiencies. Exceptional design and pre-fabricated construction minimize installation and maintenance expenses.

fin-fans are available in forced or induced draft designs with a wide range of capacities. Many accessories are available to solve special drive, control and weather problems.

Send for Griscom-Russell Bulletin 2400.



G-R Designed for the Petrochemical Field

Reboilers • G-Fin Sections • Condensers • Plate Fin Exchangers • Longitudinally and Helically Finned Tubing • Bentube Evaporators • Liquid Heaters • Tubular Heat Exchangers • Solution Heaters • Oil and Water Coolers • Tank Heaters • Gas Coolers • Bentube Sections

THE GRISCOM-RUSSELL COMPANY

MASSILLON, OHIO

A SUBSIDIARY OF **HAMILTON-THOMAS CORPORATION**

HEAT EXCHANGE EQUIPMENT FOR THE PETROCHEMICAL INDUSTRY

GR 380

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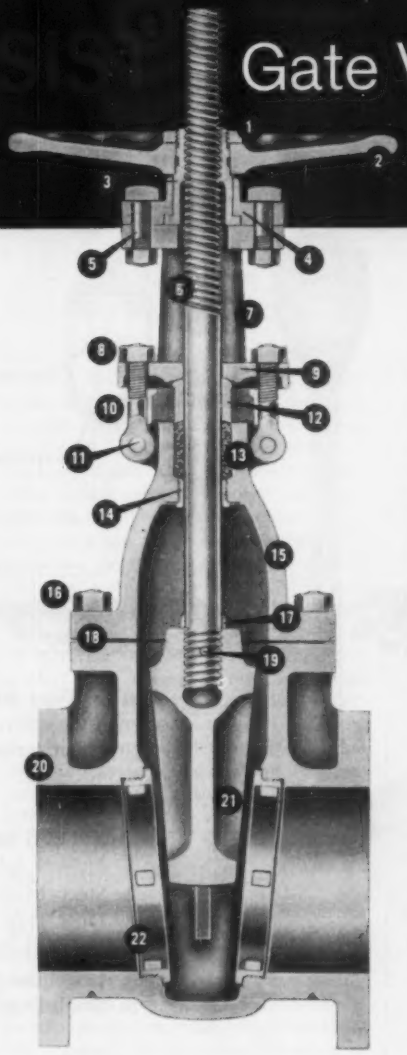
You extend valve life in Corrosive and Erosive services TWO WAYS when you Specify for Gate Valves, too



No. 1... when you specify "Jenkins" you get not merely "Ni-Resist" metal but you get Type 2 Ni-Resist Cast Iron! That affords extra resistance to acids, salt and alkaline solutions, sea water, brine and other corrosive and erosive fluids, vapors or gases. It is copper-free and will not contaminate or discolor the materials controlled.

Type 316 Stainless Steel is used for the wedge, spindle and other trimmings to give you a combination of metals which have remarkable ability to withstand destructive service.

No. 2... you get all the excellence which the Jenkins Diamond trademark has represented for nearly a century. The superior design and construction are visible here. Equally important superiorities which show up only in the records of long service and low maintenance are the close grain and high density of Jenkins castings... the precision of Jenkins machining... the rigid inspection and testing which every Diamond-marked valve undergoes.

It costs no more to buy Ni-Resist Gates made by Jenkins. And, it may cost much less to USE them. Write us, or ask your Jenkins Distributor for information folder No. 205.

1 Bronze yoke bushing nut
2 Handy grip iron wheel
3 Bronze yoke bushing
4 Iron yoke cap with zerk fitting for lubricating bushing
5 Steel yoke cap bolts and nuts
6 TYPE 316 STAINLESS STEEL spindle
7 NI-RESIST CAST IRON, TYPE 2, yoke
8 Bronze eye bolt nuts
9 Malleable iron gland flange
10 Steel gland eye bolts
11 Steel gland lug bolts and nuts
12 TYPE 316 STAINLESS STEEL gland
13 Teflon impregnated asbestos packing
14 TYPE 316 STAINLESS STEEL bonnet bushing
15 NI-RESIST CAST IRON, TYPE 2, bonnet
16 Steel bonnet bolts and nuts
17 TYPE 316 STAINLESS STEEL spindle ring
18 Asbestos gasket
19 TYPE 316 STAINLESS STEEL wedge pin
20 NI-RESIST CAST IRON, TYPE 2, through-port body
21 TYPE 316 STAINLESS STEEL solid I-beam wedge
22 TYPE 316 STAINLESS STEEL seat rings

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
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Sold Through Leading Distributors Everywhere

JENKINS BROS., 100 Park Avenue, New York 17, N. Y.

Send folder No. 205 describing Ni-Resist Gate Valves

Name & Title.....

Company.....

Address.....

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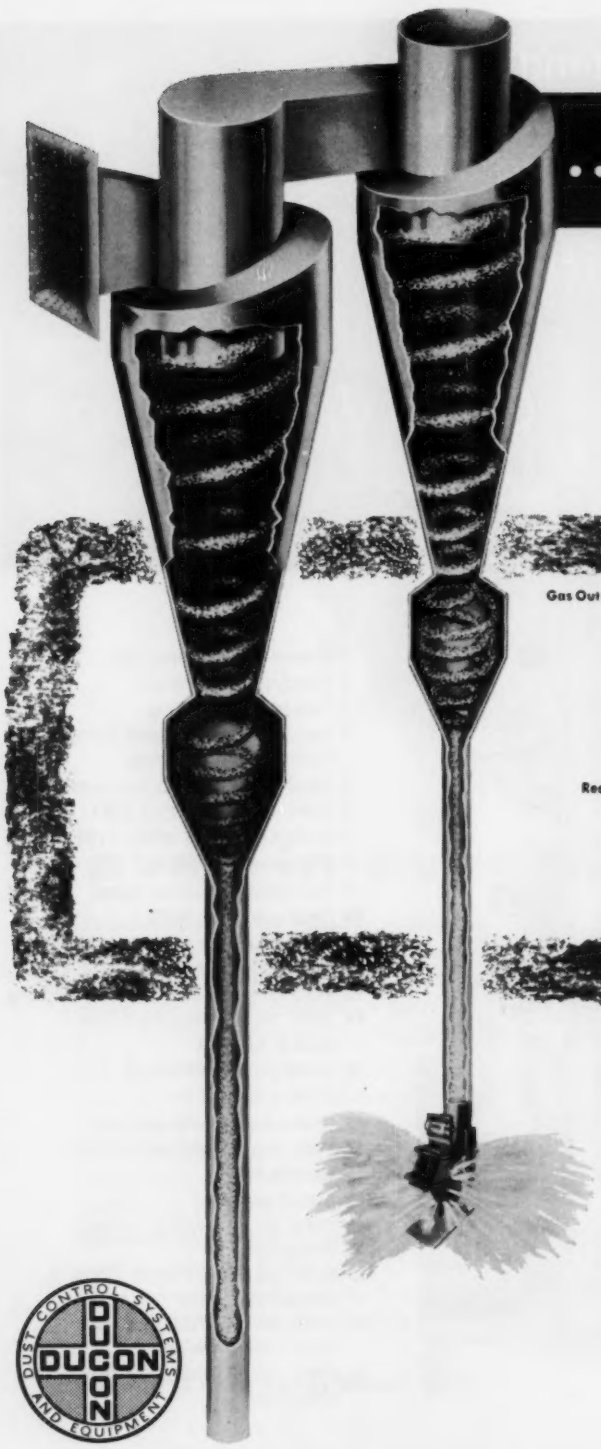
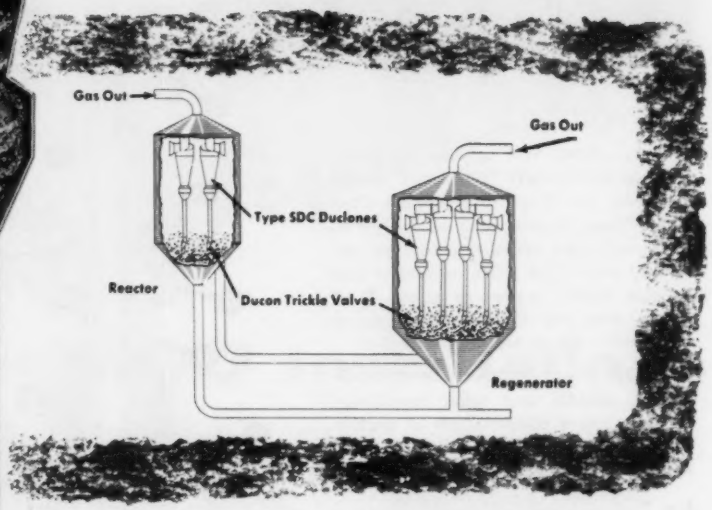
. . . in catalyst recovery

Type *SDC* DUCLONES assure

- *HIGH EFFICIENCY*
- *LOW PRESSURE LOSS*
- *LONG SERVICE LIFE*





Ducon Type SDC Catalyst Recovery Duclones have earned the approval of the world's leading refineries for their effectiveness in catalyst recovery and other fluid bed processes.

The exceptional performance of Type SDC Duclones is the result of 5 unique design features:

1. Helical Inlet to reduce turbulence
2. Steep Cone for improved dust separation
3. Dust Trap to reduce entrainment
4. Scroll Outlet to provide low resistance, tangential gas exit
5. Small Diameter for high efficiency

For additional information on Type SDC Duclones send for Bulletin C-2058.

DUCON — DUST CONTROL SYSTEMS AND EQUIPMENT

the name in DUst CONtrol

THE Ducon COMPANY INC.

147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK

Canadian Branch:
THE DUCON COMPANY of CANADA, Ltd.,
1131 Pettit St., BURLINGTON, ONTARIO

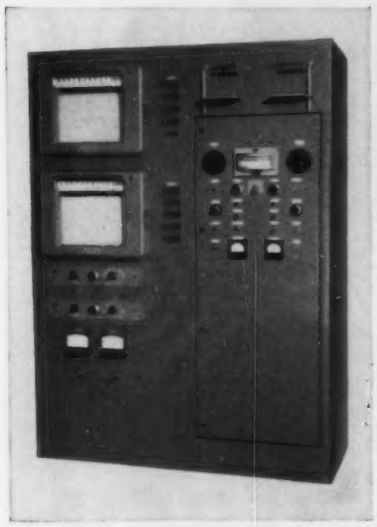
CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

BARBER COLMAN

THE BARBER-COLMAN *Analyzer*

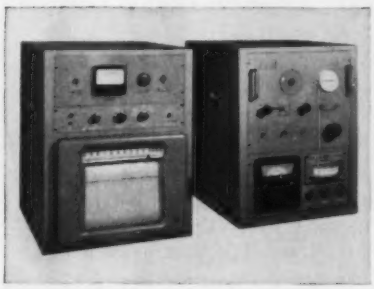
Wheelco Instruments Division

THE CHROMATOGRAM IS THE PROOF



WHEELCO MODEL 10

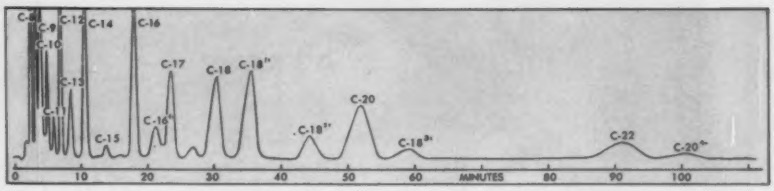
Single or dual operation with packed or capillary columns. Individual temperature control for sample injection, column, and detector. Electronic integrator and automatic readout for fast, accurate reading, optional.



WHEELCO MODEL 20

Compact, portable unit for laboratory and industrial use. Designed to accept capillary or coiled packed columns. Individual temperature controls. Integrator and automatic readout, optional.

Look for difficult separations and completely resolved peaks



For top efficiency, accuracy and reliability, a chromatograph must be able to make difficult separations and complete resolution of peaks. The above chromatogram is typical of the efficiency of Barber-Colman Gas Chromatography. This chromatogram shows complete separations of methyl esters of fatty acids using an eight foot column packed with succinate polyester of ethylene glycol. Column temperature was 170°C and chart speed was 30 inches per hour. Other chromatograms from many types of runs are in our files awaiting your study. These chromatograms are proof of the accuracy and reliability of Barber-Colman Gas Chromatographs. As the first American manufacturer of ionization detection systems, continuing research and development at Barber-Colman has set standards for America's industrial and laboratory requirements for gas chromatography. New techniques and accessory items developed by Barber-Colman have already done much to further the art of chromatography. One of these, for example, is a new tritium detector. This detector gives even less baseline noise than strontium-90; i. e. one-tenth that of radium. This, of course, provides greater sensitivity. Other Barber-Colman items that increase the versatility of the instrument are a flame detector (as an accessory), separate temperature controls for the column heater, flash heater and detector, plus adjustable sample splitter, effluent splitter, automatic or manual attenuation, events marker and automatic readout. Why not write for complete information?

Application Flexibility

Barber-Colman Chromatographs permit accurate recording and full-range control over all phases of operation. The components and assemblies are readily accessible to provide the flexibility necessary for maximum range of applications. For instance, the ionization detector is available with many combinations of radioactive sources, anodes and insulators to suit a wide range of analytical requirements. One user reports that with his Barber-Colman Model 20 equipped with an ionization detector he has been able to detect trace components in concentrations of one part per billion or less. Superiority of this type makes Barber-Colman probably the most flexible chromatograph commercially available.

Nationwide Network of Sales and Service Representatives

Investigate the features that are significant to your chromatography requirements by calling the nearest Barber-Colman sales and service office.

Wheelco Instruments Division

BARBER-COLMAN COMPANY

Dept. E, 1597 Rock Street, Rockford, Illinois, U.S.A.

BARBER-COLMAN of CANADA, Ltd., Dept. E, Toronto & Montreal, Can. Export Agent: Ad. Auriema, Inc., N.Y.

Check these improved 1960 insulations

BEH
BALDWIN-EHRET-HILL

you'll want them in your new specifications

Take a Fresh Look at MONO-BLOCK®

One Block Insulates up to 1800 F

B-E-H Mono-Block now spans the full range up to 1800 F; provides lower thermal conductivity, 0.63 at 800 F. Its long, spun mineral wool fibers form a strong, rigid block that stands abuse in handling — yet impales easily over studs or pins without pre-drilling, speeding application. Mono-Block provides an excellent surface for applying a single insulating-finishing coat of B-E-H Super Powerhouse Cement. This may be trowelled directly on the block — saving the expense of wire mesh and the time it takes to apply it.

Baldwin-Ehret-Hill has thrown a new light on insulation performance which will pay you well to consider in writing specifications. Continuing research and resulting product improvements meet advanced concepts in the design and engineering of new installations. You can depend on the B-E-H line of thirty specialized insulation products, for service from sub-zero to 1900 F, to give you better performance, easier application, and lower installed cost. To bring your specifications up to date, write for our 1960 catalog or see it in your Sweet's File.

NOW IS THE TIME TO UPDATE YOUR SPECIFICATIONS WITH . . .

BALDWIN-EHRET-HILL

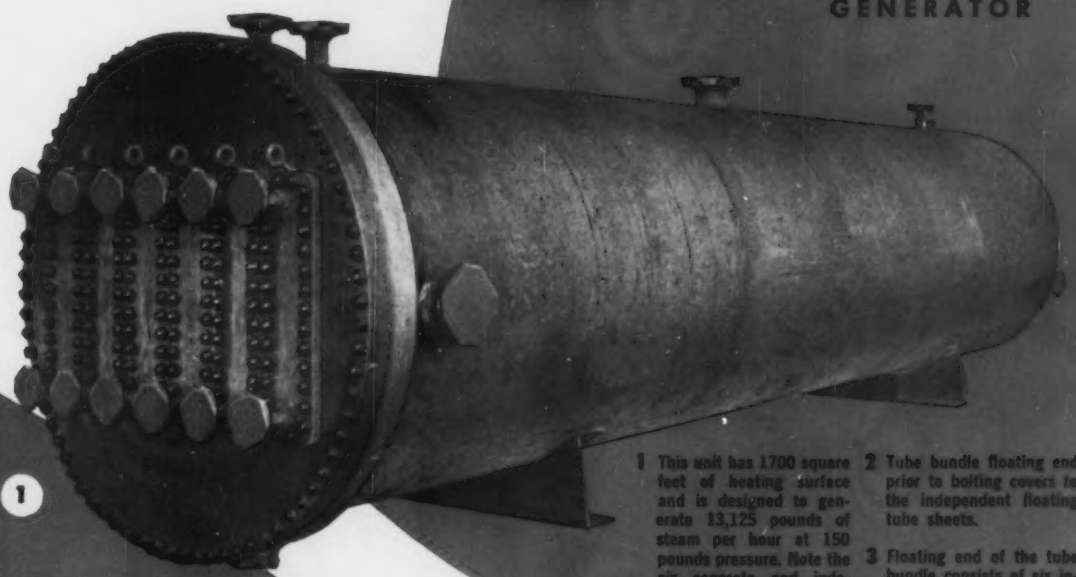
100 Breunig Ave., Trenton 2, N. J. Incorporated • 1897

THE COMPLETE LINE OF INSULATIONS for use SUB-ZERO TO 1900 F.

CONTRACT APPLICATION SERVICE FROM COAST TO COAST

Consolidate all your plant "waste heat" sources with this unique

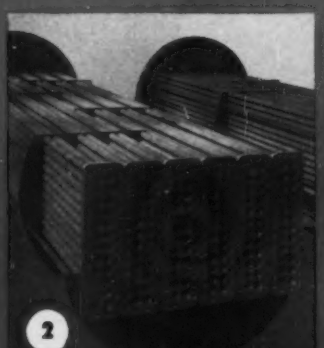
Vogt multi-stream STEAM GENERATOR

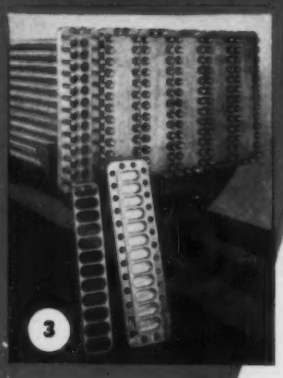


1 This unit has 1700 square feet of heating surface and is designed to generate 13,125 pounds of steam per hour at 150 pounds pressure. Note the six separate and independent circuits of the tube bundle stationary end which is bolted to shell.

2 Tube bundle floating end prior to bolting covers to the independent floating tube sheets.

3 Floating end of the tube bundle consists of six independent circuits each with its own tube sheet, gasket and cover with special integral baffles.





Put unused sources of heat to work by concentrating them in a Vogt Multi-Stream Steam Generator.

The purpose of the design is twofold. First, it is possible to utilize several hot streams if there is insufficient heat recovery in one stream. Second, if one hot stream is used it can be split into several circuits whereby the flow is only one-tube-per-pass. This prevents plugging of tubes when handling fouling or polymerizing liquids.

The design incorporates a number of separate circuits enclosed in a single shell. The circuits are independent of each other and each stream can be separately shut off and cleaned without affecting the operation of the others. Thus the unit can be kept continuously on the line by operating one or more streams.

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Bulletin HE-8 illustrates many unusual as well as standardized types of heat exchangers. Write for your copy to Dept. 24A-XPR.

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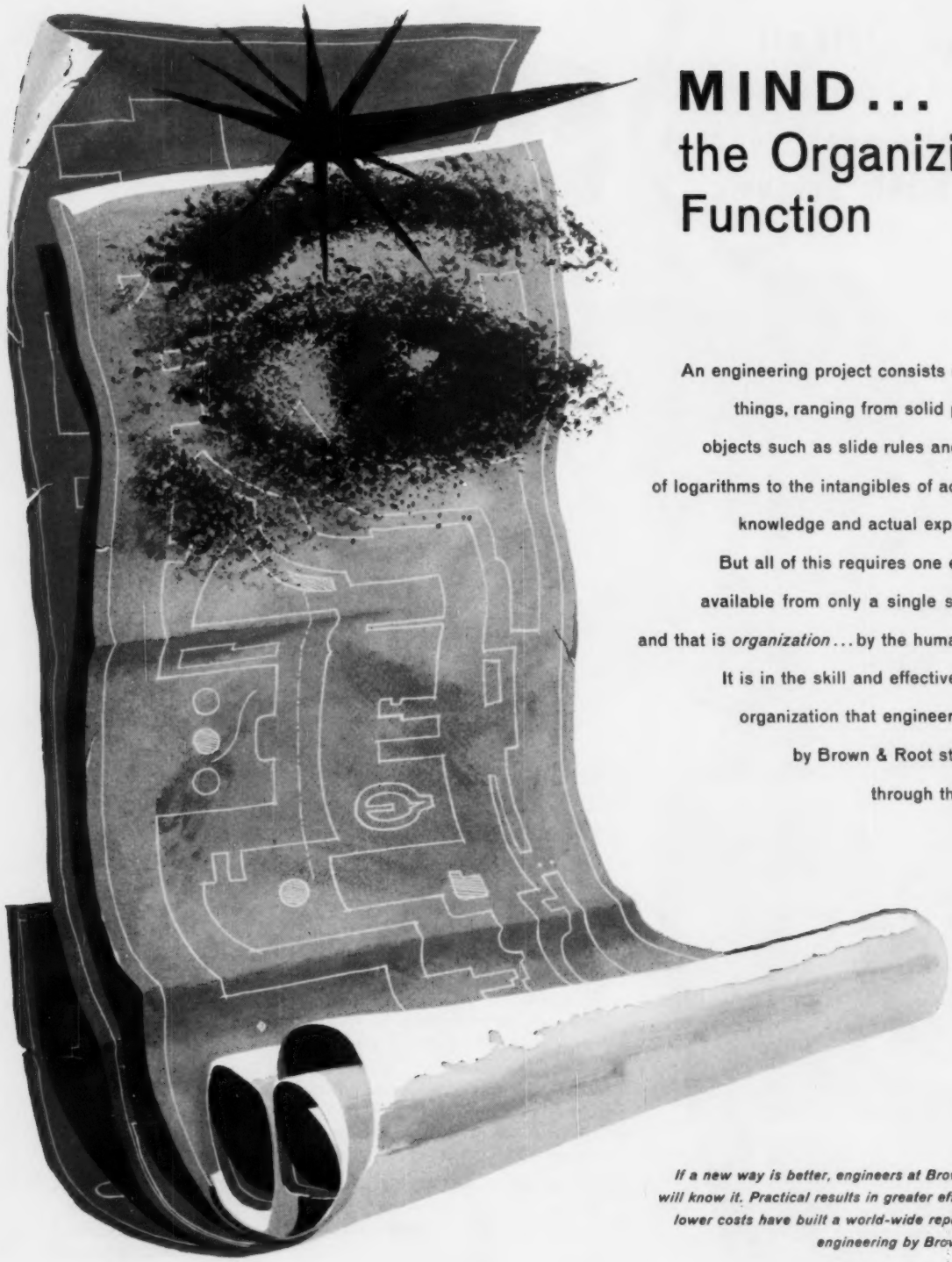

MIND... the Organizing Function

An engineering project consists of many things, ranging from solid physical objects such as slide rules and tables of logarithms to the intangibles of academic knowledge and actual experience. But all of this requires one element, available from only a single source—and that is *organization*... by the human mind. It is in the skill and effectiveness of organization that engineering jobs by Brown & Root stand out, through the years.

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Refractory concrete protects while it insulates

For heater linings, refractory concrete made with LUMNITE calcium-aluminate cement and suitable aggregates offers two vital services. It provides a dependable heat-resistant layer for structural steel parts, and it insulates the unit to reduce heat loss (and fuel costs).

Linings of refractory concrete are light in weight, yet structurally strong through a wide temperature range. Placement is easy and economical, since refractory concrete made with LUMNITE cement can be precast, gunited, poured or troweled into place. In any case, service strength is reached within 24 hours.

For extra convenience, castables containing LUMNITE cement are available from leading manufacturers of refractories. These packaged mixtures are ready to use with just the addition of water. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

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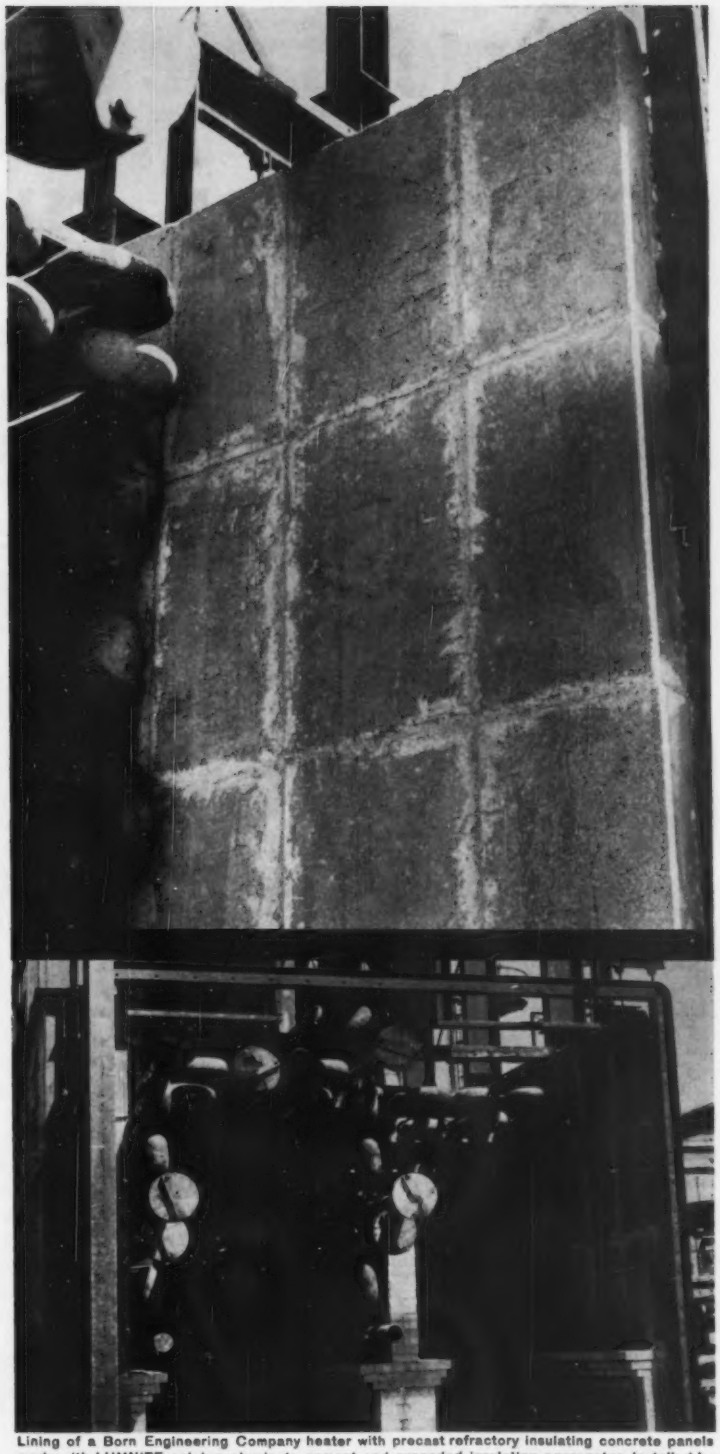

Lining of a Born Engineering Company heater with precast refractory insulating concrete panels made with LUMNITE calcium-aluminate cement and expanded insulating aggregates. Installed by Blaw-Knox Company at Ashland Oil & Refining Company, Canton, Ohio.

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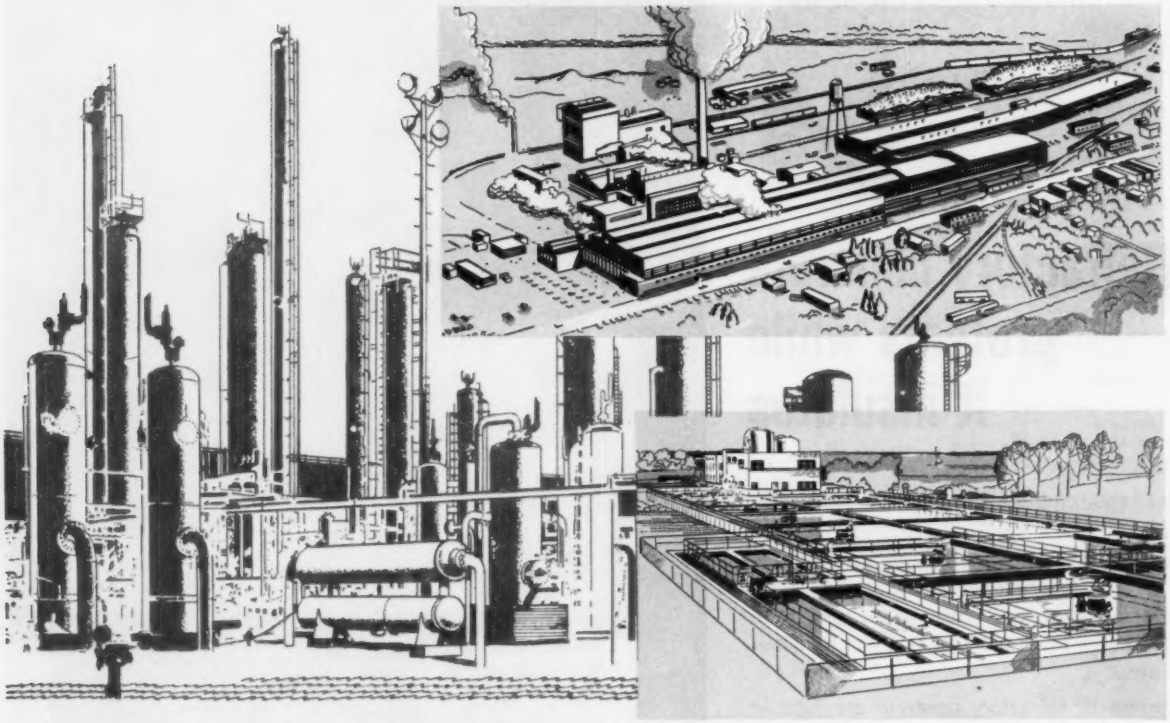

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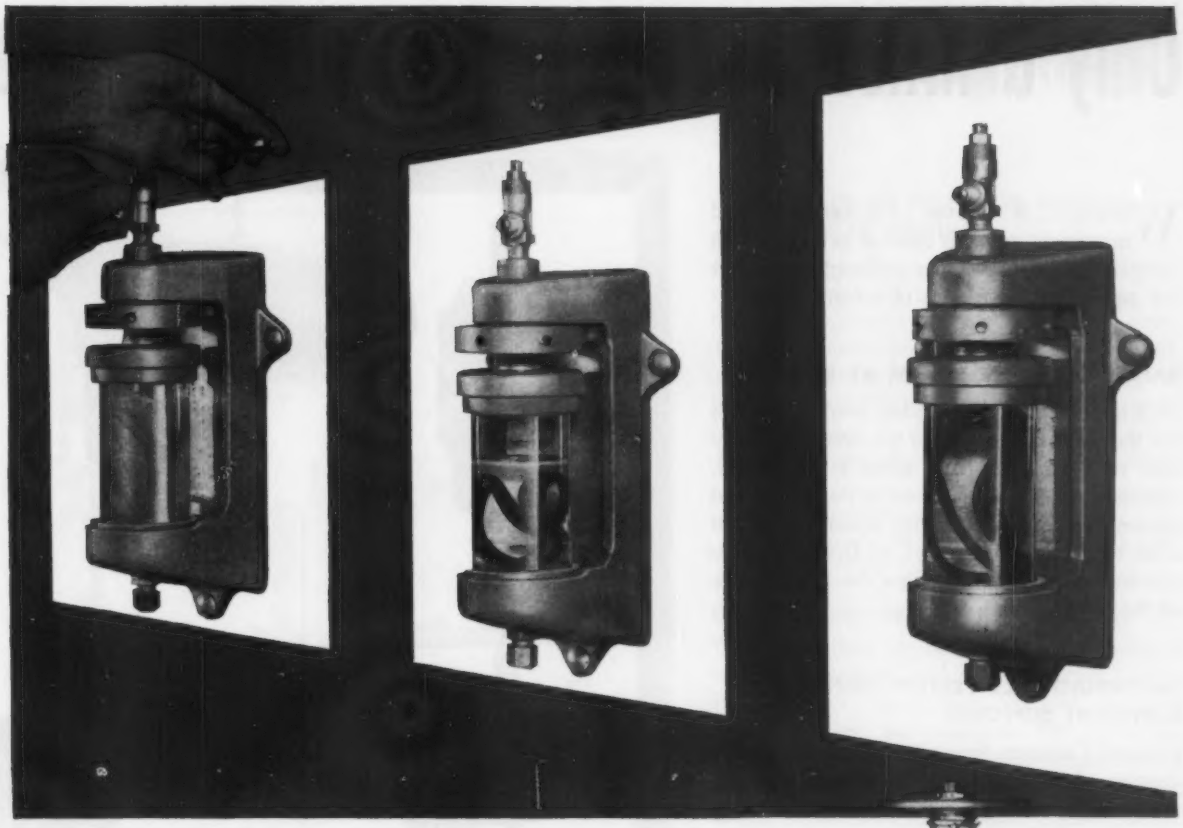


Kerotest Valve Parts Get the ALL CLEAR FROM BOMBS

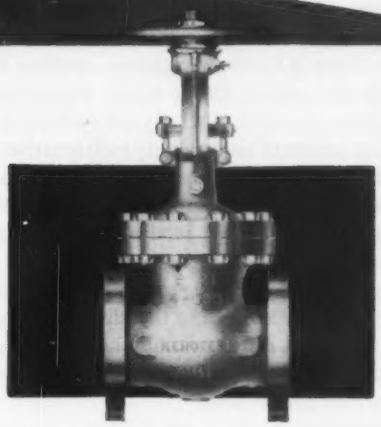
All materials and parts that go into Kerotest Valves must first get the all clear in these pressurized material test bombs at the Kerotest laboratories. Packings, plastics, gaskets, O-rings, seat rings, steel, and other materials are accepted as suitable only after they've withstood the deteriorating effects of various gases, vapors, liquids and refrigerants for specified test periods.

Kerotest quality controls are applied from the initial development and engineering phase to the final assembled valve. For those who specify and use Kerotest Valves these high standards of material and production quality mean greater valve value per dollar. With Kerotest there's minimum risk of valve failure in service and improved operating efficiency with less maintenance.

Kerotest Cast Steel Gate Valves

High quality Kerotest cast steel gate valves are available in primary service pressure ratings ranging from Series 150 to Series 1500. They are supplied in various combinations of body and trim material for all types of service in oil, gas, steam, water, chemical, petro-chemical, marine and industrial installations.

Send for your free copy of the new, informative Kerotest booklet. It's packed with working tables, dimensions, specifications and other helpful information.



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Quality Controlled Features

- Reinforced wall sections guard against unusual strains — erosion and corrosion.
- Built for repacking under pressure in the full open position.
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- Threaded, bottom seating type seat rings. Made without protruding lugs to permit full clear way opening through valves.
- All yokes made to withstand rough handling and equipped with lubrication fitting to stem nut.

There is a Kerotest Cast Steel Valve available for every class and condition of service.

KEROTEST MANUFACTURING COMPANY

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In Canada . . . Kerotest Cast Steel Valves are manufactured and distributed exclusively by Guelph Engineering Company, Guelph, Ontario, Canada

KEROTEST®

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Only Grinnell has a complete line of pipe

With 8 . . . 9 . . . even 10 inches of thermal movement not a bit unusual in today's high temperature piping systems, complete support for piping in all positions of travel is vital.

SAFETY OF ENTIRE SYSTEM AT STAKE

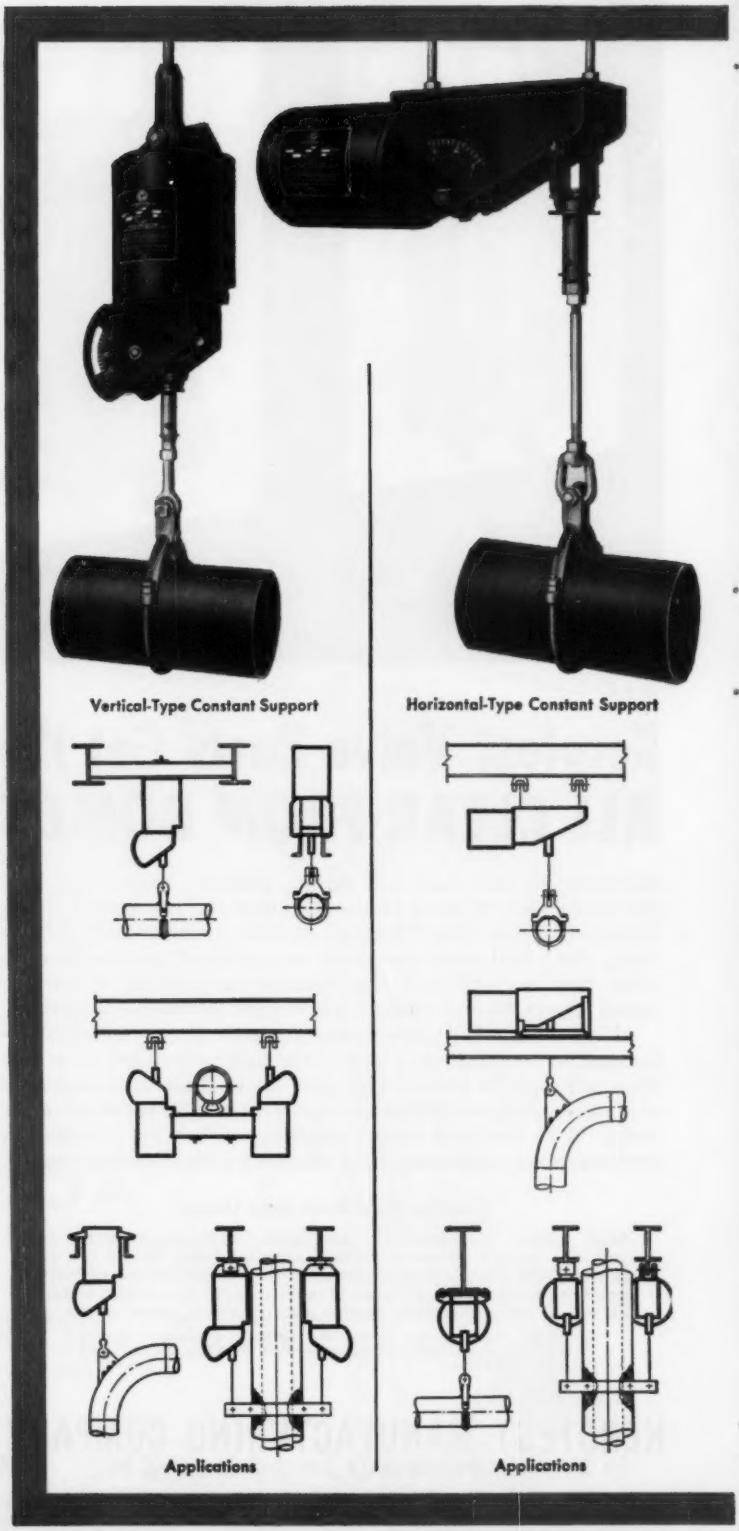
Helical coil springs are widely used to provide for thermal expansion. But the design or selection of flexible supports often is haphazard. Unless careful study is given to the design and choice of spring supports, the transfer of weight from one hanger to another, or from hanger to terminal points, can endanger the safety factor of the entire system.

MATHEMATICALLY PERFECT GRINNELL CONSTANT SUPPORTS

Grinnell Constant Supports are the result of a century of experience in the industrial piping field. A patented geometric design, exclusive with Grinnell Constant Supports, assures mathematically perfect load support throughout all positions of travel. There is also a full 70 percentage points of adjustability built into them. No less than 10 percent of this adjustability is allowed either side of calibration for plus or minus change in load. Field readjustments are easily made by turning a single load adjustment bolt. These hangers are designed to provide uniform supporting force equal to the pipe load throughout the travel range — and should be used at selected points on critical lines, as for example at turbine connections.

Available in 11 Different Types

Grinnell Constant Supports are available in eleven types for a complete choice of mounting positions; above, between, or below structural steel. This choice includes both vertical and horizontal design to fit compactly into available headroom space. Even with this wide choice, Grinnell Constant Support Hangers provide mathematically perfect support through *all* ranges of travel, regardless of field adjustments.



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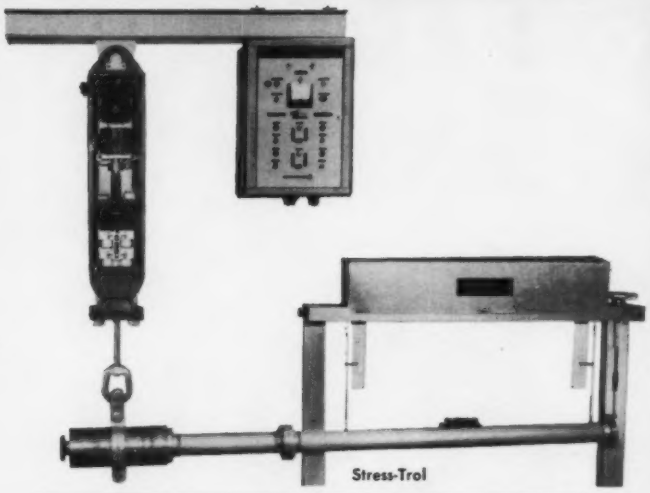
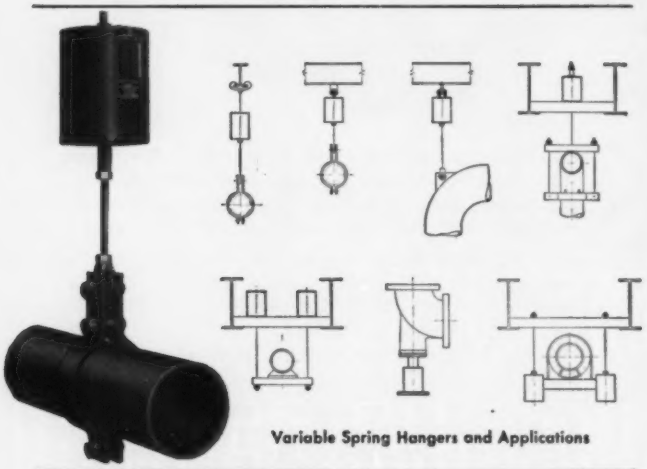
hangers to provide for thermal expansion

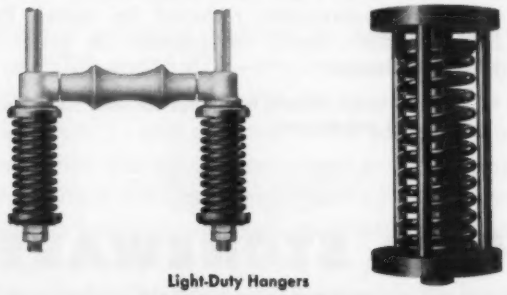


Stress-Trol



Variable Spring Hangers and Applications

Vibration Control and Sway Brace



Light-Duty Hangers

GRINNELL STRESS-TROL* FOR POSITION AND/OR LOAD CONTROL

Keeping the footage of high pressure-high temperature fabricated piping to a minimum has become important because of high piping costs. This can be accomplished by reducing the length of long expansion bends, but providing support for shorter, less flexible lengths of piping presents a new problem. Grinnell Stress-Trol, a motor operated device, solves this problem. It provides:

Position Control — that minimizes stresses in piping and reactions on connected equipment.

Load Control — that is constant support with unlimited load and travel capacities.

GRINNELL VARIABLE SPRING HANGERS

When pipe lines are subject to relatively small vertical movement, and do not require a constant support type hanger, Grinnell Variable Spring Hangers are available. The maximum variation in supporting force for standard spring models per ½ inch deflection is 10% of rated capacity. Grinnell offers these hangers in 21 sizes — in short, standard and double spring models, plus a special corrosion-resistant model. There are 7 different methods of attachment.

GRINNELL VIBRATION CONTROL AND SWAY BRACE

When necessary to prevent undesirable movement in lines, Grinnell Vibration Controls and Sway Braces of the energy storing and instant-acting counter force type are recommended. They dampen vibration, oppose pipe sway and absorb shock.

GRINNELL LIGHT-DUTY SPRING HANGERS

Finally, simple and inexpensive adjustable light-duty spring hangers often are all that's required to support piping safely. Grinnell has a complete line of light-duty hangers. They are designed for easy installation and quick, accurate alignment of piping.

Whatever your pipe suspension needs, Grinnell can supply them. Grinnell Company, 260 West Exchange Street, Providence 1, Rhode Island.

*Patents Applied For

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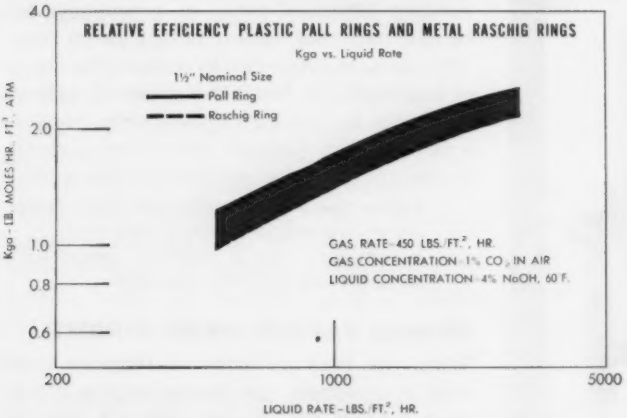
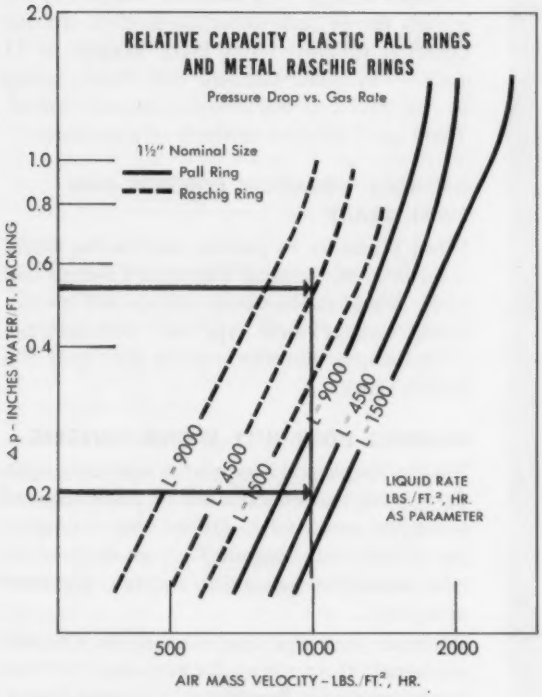
NOW PALL RINGS in PLASTIC



Kga data, obtained in one of our 30" experimental towers, reflects the much greater efficiency of plastic Pall Rings.



Pressure drop data likewise reflects the high capacity of plastic Pall Rings. For example, pressure drop through metal Raschig Rings at a gas rate of 1000 lbs./ft.², hr., and a liquid rate of 4500 lbs./ft.², hr., is almost three times greater than through plastic Pall Rings.

The remarkably efficient Pall Ring, first introduced on the American market in 1957, in metal, is now available in polypropylene and high density polyethylene;* in four sizes: ⅝", 1", 1½" and 2".

Pall Rings in plastic offer the same striking advantages of low pressure drop and high capacity at less than one-fourth the weight. (For example, 1½" Pall Rings in carbon steel weigh approximately 23½ lbs. per cu. ft. In plastic, only 4¼ lbs.)

Take a look at the graphs showing comparative efficiency data and capacity data for metal Raschig Rings and plastic Pall Rings . . . data prepared from test runs in one of our 30" diameter experimental towers. The differences stem entirely from the characteristics of the two rings. In the Pall Ring the inner projections of the wall become active working surfaces as opposed to the relatively "dead" inner wall of the Raschig Ring.

The conclusions are inevitable: tower volume can be substantially reduced by using Pall Rings (either metal or plastic) in place of Raschig Rings.

***On special order, Plastic Pall Rings can also be supplied in PVC and polystyrene.**

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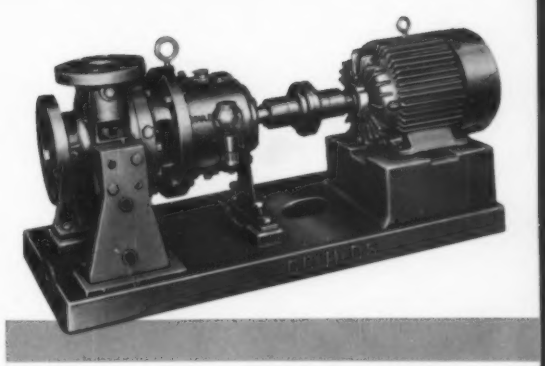
200° to 650° REFLECTIONS ON THE INTERMEDIATE-RANGE

A petroleum pumping problem lies between the temperatures of 200° and 650°F—the intermediate range. Pumps that handle these temperatures are usually built to stand far greater heat . . . and are much more pump than is needed.

Goulds has designed a petroleum process pump that fits into this critical area of temperatures like a glove . . . by adding one hundred twelve years of experience to a young and vigorous talent for matching the pump to the problem.

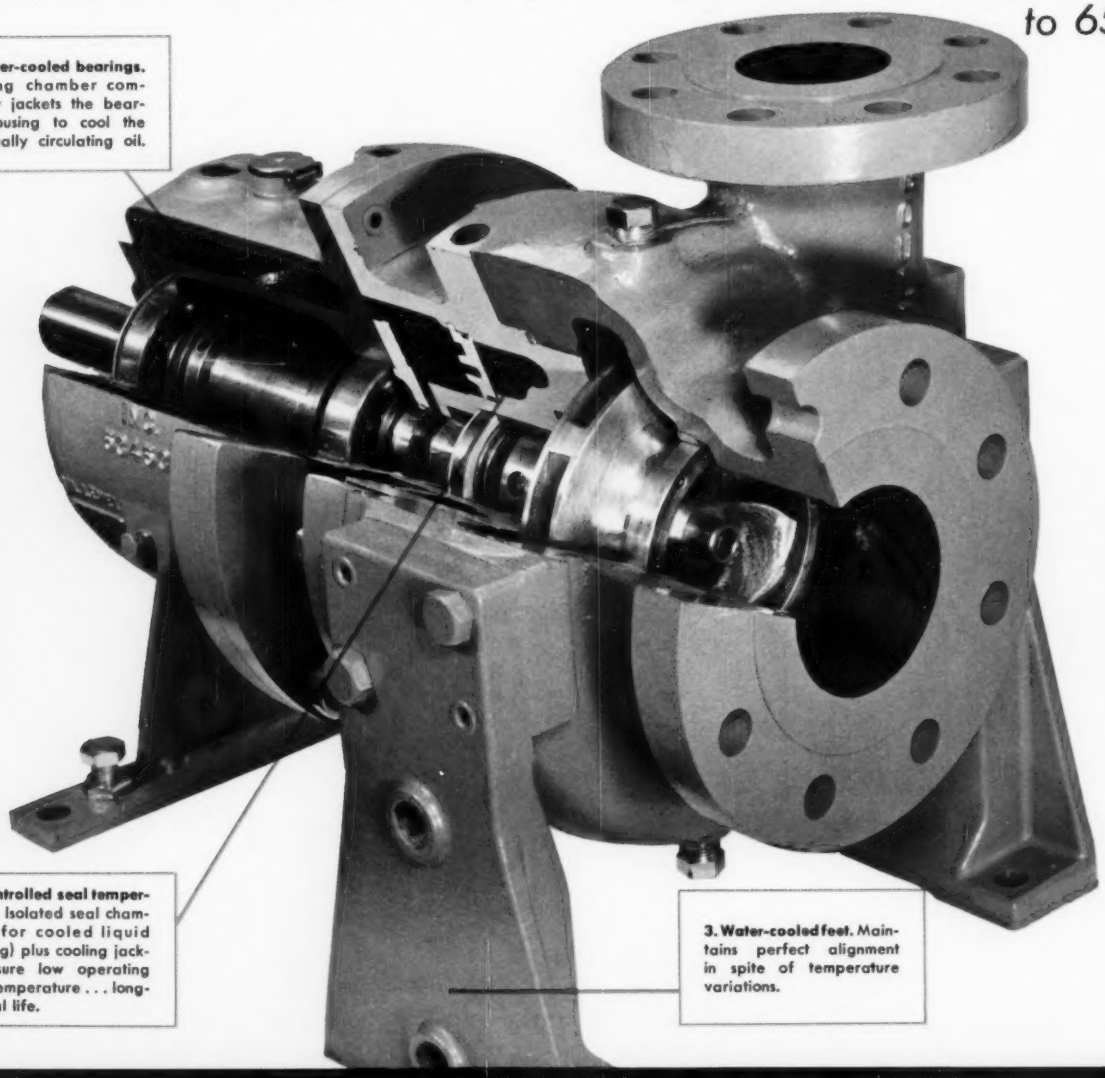
When you turn this page, you'll see inside the intermediate-range pump. And you'll get a glimpse of other Goulds pumps planned with the petroleum industry in mind.



AN INSIDE LOOK AT
INTERMEDIATE-RANGE DESIGN

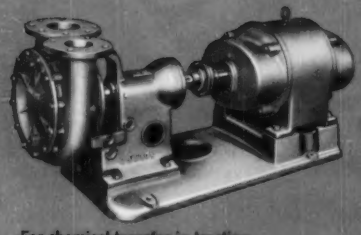
Here's why the Goulds petroleum process pump handles temperatures to 650°F

1. Water-cooled bearings. Cooling chamber completely jackets the bearing housing to cool the continually circulating oil.

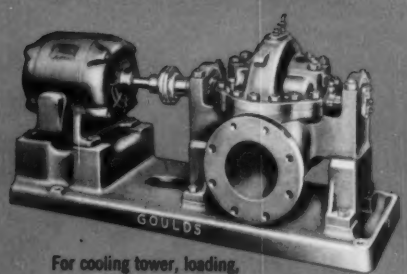


2. Controlled seal temperature. Isolated seal chamber (for cooled liquid flushing) plus cooling jacket insure low operating seal temperature . . . longer seal life.

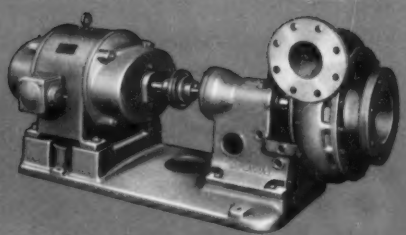
3. Water-cooled feet. Maintains perfect alignment in spite of temperature variations.



For chemical transfer in treating and lube plants



For cooling tower, loading, and reflux service



For tank farm and bulk service

Intermediate-range design lowers initial cost

Practical features cut maintenance cost

Goulds petroleum process pump Model 3775, built to API 610 specifications, gives you the economies of practical design.

Back pull-out makes seal replacement and maintenance easy. With the use of a spacer coupling, rotating parts can be removed without disturbing pipe connections or drive. *A millwright can do it alone.*

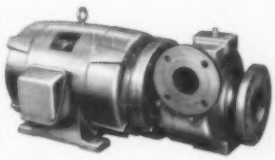
Choose your own seal design. Single, double, balanced or unbalanced mechanical seals can be supplied to suit your specific requirements.

Low spare parts inventory. All eleven sizes of the Model 3775 are built on the same bearing frame. The resultant standardization and interchangeability give you maximum economy in inventorying spare parts.

High working pressures. The Model 3775 has been designed expressly to meet the exacting requirements of the petroleum and petrochemical industries. It is an enclosed impeller-type centrifugal pump, centerline mounted with vertically split casing. It pumps a maximum of 850 gpm, handles pressures to 550 psi.

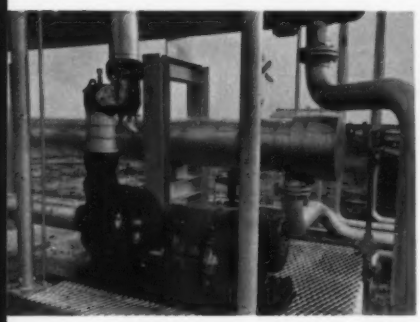
For complete specifications, construction details, and pressure-temperature chart, just send us the coupon below.

Close-coupled version



Goulds Model 3675 is a close-coupled version of the Model 3775, incorporating the same liquid end as the frame-mounted type but providing the compactness found only with integral pump-motor designs. Eleven sizes provide broad rating coverage with capacities to 850 gpm, heads to 350 ft. Maximum temperature is 275°F and maximum working pressure 550 psi.

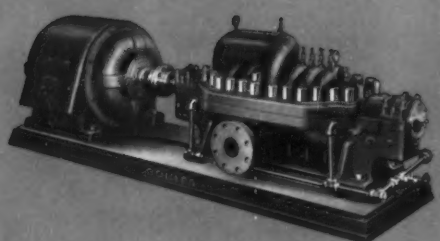
The Model 3775 serves a broad range of applications



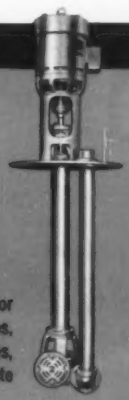
LOW TEMPERATURES. Low-temperature applications are met equally as well as high-temperature ones. Shown above is a 3775 1½x2-9 on propane-circulating service rated at 70 gpm, 210 ft, 10°F liquid. Compact casing design with internal seal flushing provides for easy lagging.

HIGH TEMPERATURES. Intermediate-range design provides a standard pump for the higher-temperature applications. Shown above is a 3775 3x4-7 on hot oil service handling 250 gpm against 130 ft. of head of 400°F oil. Bearing cooling and seal chamber cooling, standard features on these pumps, provide the essential features necessary for this engineered application.

NORMAL SERVICE. Where the need is for steel case and high working pressures, as on light ends, reflux, and intercooler service, Goulds Model 3775 is ideally suited. Shown above is a typical service handled by a pair of 2x3-7 pumps rated 150 gpm at 150 ft, propane at 100°F and 200 psi suction pressure.



For pipe line and water flood injection



For corrosives, slurries, and waste

GOULDS PUMPS, INC.

Dept. I R-60, Seneca Falls, N.Y.

Please send me Bulletin 724.1 giving details and specifications on the Model 3775.

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An Accurate, Time-Saving Way To Electrical Labor Estimating . . .

ESTIMATOR'S ELECTRICAL MANHOUR MANUAL

By John S. Page and Jim G. Nation

Price $10.00

Provides an accurate method of estimating direct labor for complete electrical installation in any given system or plant.

Before you think in terms of labor dollars for an estimate, there are many things to be considered. The most important of them being what is called productivity efficiency coupled with production elements.

The scores of manhour tables in this manual were compiled after detailed analysis of many time and method studies . . . covering all phases of electrical installations.

The manual points out how to arrive at a composite rate using productivity efficiency and production elements. With the composite rate, manhour estimating can be applied with equal validity to any electrical job, in any location.

The authors, estimators by profession, have found after much comparison on many projects, that production efficiency percentages can be classified into five categories: very low, low, average, very good and excellent. Production elements can be grouped into six different listings: general economy, project supervision, labor relations, job conditions, equipment, weather.

Using the above experience, the authors have devised an accurate and convenient method of estimating direct labor for complete electrical installation for any given system. Thus, by means of this Manual, the reader has a dependable method of obtaining a production efficiency percentage by applying all known local conditions and variables . . . plus a method of obtaining a complete direct labor rate for the craft or crafts involved in the various operations.

Subject areas covered include: Section 1—Conduit, Boxes and Fittings; Section 2—Service and Feeder Wiring; Section 3—Branch Circuit Items; Section 4—Lighting Fixtures; Section 5—Panelboards and Cabinets; Section 6—Safety Switches; Section 7—Hangers and Fasteners; Section 8—Underfloor and Buss Ducts; Section 9—Starters and Motors; Section 10—Mounting Transformers; Section 11—Outside Construction; Section 12—Underground Duct and Cable; Section 13—Communications and Signal Systems; Section 14—Demolition, Excavation and Concrete; Section 15—Technical Information.

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- Miscellaneous fasteners
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- Underfloor steel ducts
- Branch circuit wiring for ducts
- Special raceways (ducts, elbows, tees, crosses, tap boxes, hangers, plug-ins, trolly duct)
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- Mounting and connecting dial type speed regulation rheostats
- Starting compressors
- 30 amp AC magnetic switches
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- Stringing wire, aerial cable, grounding
- Primary & secondary protective devices
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- Distribution line regulators & capacitors
- Miscellaneous overhead service items
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- Cement asbestos duct installation
- Lead covered and direct buried cable
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- Clock, program and fire alarm systems
- Hospital signaling systems
- Intercommunications, public address systems
- Miscellaneous signal system devices
- Raceway, cable and wire, power supply
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- Cutting holes in wall, excavation for poles
- Machine excavation for ducts and manholes
- Hand excavation for ducts and manholes
- Rock excavation for ducts & manholes
- Shoring and bracing trenches
- Disposal of excavated material
- Backfilling and tamping
- Duct encasement and manhole forms
- Duct encasement and manhole concrete

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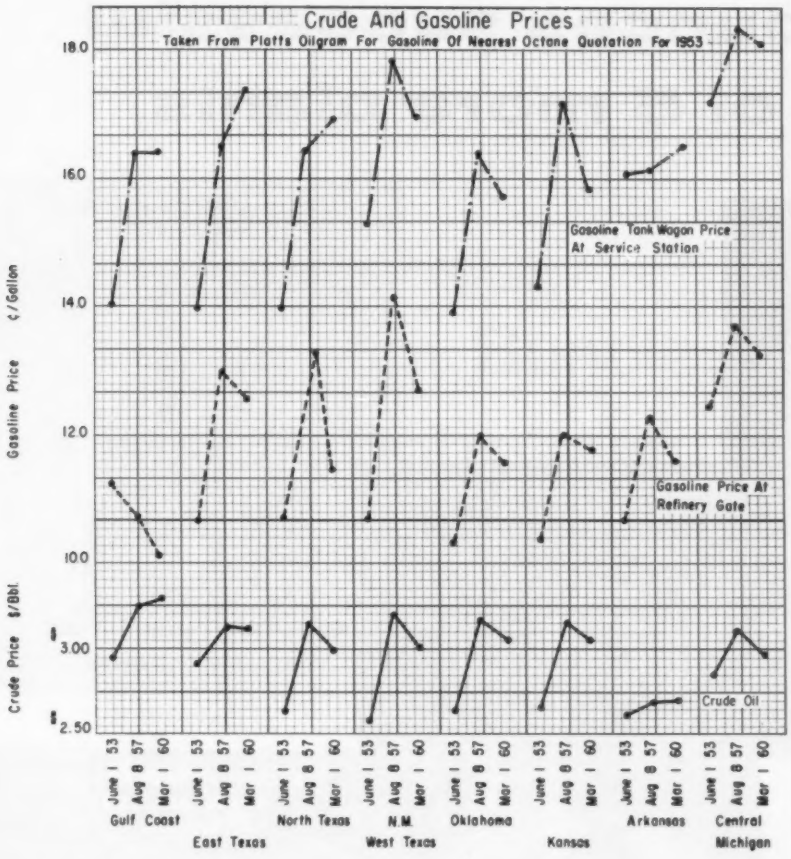

To The Editor:

The accompanying chart showing crude, refinery crude, refinery gasoline and gasoline tank wagon prices as of June 1, 1953 and March 1, 1960 may be of interest to you as indicative of the impact from low cost foreign imports and low cost unprorated domestic production from other states, and unprorated production of crude (distillate) and finished products by recycling plants.

You will note tank wagon prices reflect, f.o.b. major integrated refineries, a price commensurate with posted prices of crude; however, the independent, or non-integrated, refiner whose prices, f.o.b. refinery are reflected by Oilgram quotations is not so fortunate. Also, Texas Gulf Coast gasoline at refinery level does not follow crude or tank wagon prices.

The forced curtailment of domestic crude production to make room for low cost imports is putting a squeeze on independent, or non-integrated, producers similar to the squeeze on non-integrated refiners, i.e., higher prices to compensate for costs beyond control of either are justified and required as against present threat of lower prices.

D. W. Hovey, President
Danaho Refining Company
Houston.

Revision of a 'How'

To The Editor:

The "How to Do It" article "Slide Rule Trick Gives Fourth Place" (Page 240) in your March issue is very interesting. The numbers 368 and 370 used in explaining Figure 2 should read 268 and 270, respectively, in order to work out mathematically. In addition, in Figure 2, the C scale is displaced one graduation too far to the right; in Figure 3, the hairline is aligned on 4.23 rather than 4.33.

B. O. Wilkins, Jr.
Port Arthur, Texas

Editor's Note—Mr. Wilkins is thanked for noting and submitting these corrections.

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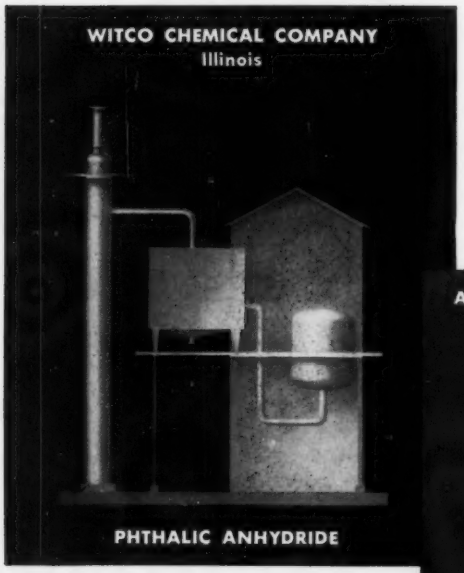

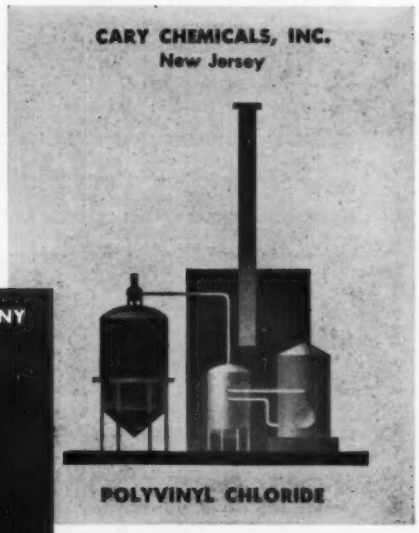

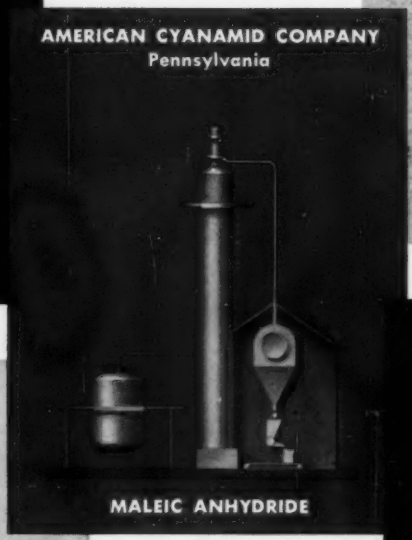

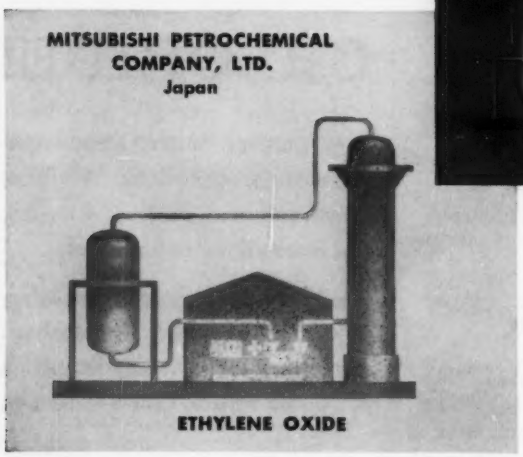

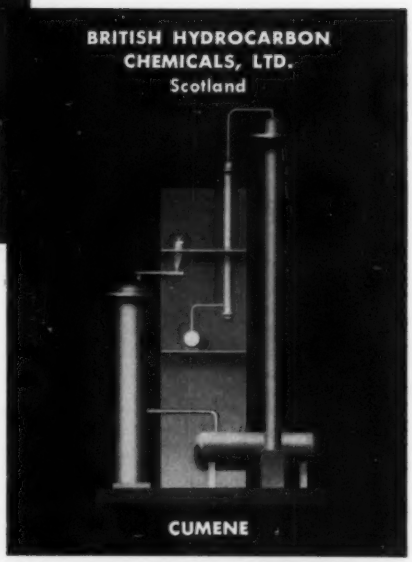

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CORROSION SESSION

Aluminum Bundles Will Work In Petroleum Service

18 case histories in 45 plants show that aluminum exchanger and condenser tubes are superior to brass, steel or alloys in certain locations

R. I. Hildebrand
Sinclair Refining Co., Harvey, Ill.

ALUMINUM is a metal considered by many refinery personnel as suitable only for pots and pans to be used in the kitchen. This belief partially results from early test work[1,2] where the metal failed rapidly under conditions which we would now consider misapplication. Other tests, however, under more advantageous conditions proved beyond doubt that aluminum does have a place in petroleum refineries. The records clearly indicate that in certain locations aluminum is superior to brass, steel, or alloy steels, and must be given consideration on that basis. Furthermore, it is economical to buy; aluminum costs approximately half as much as brass and, roughly, only 30 percent more than steel (Table 1).

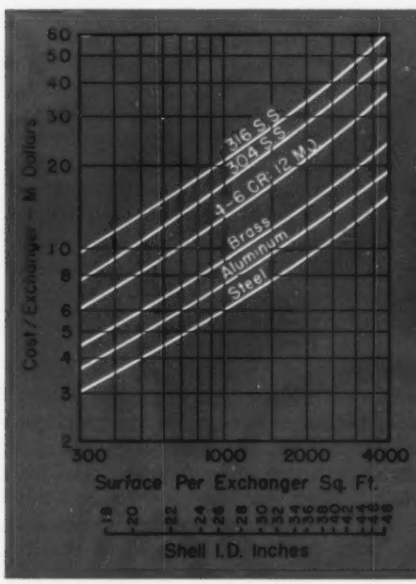

FIGURE 1—Cost of complete exchangers with steel shells and various types of bundles.

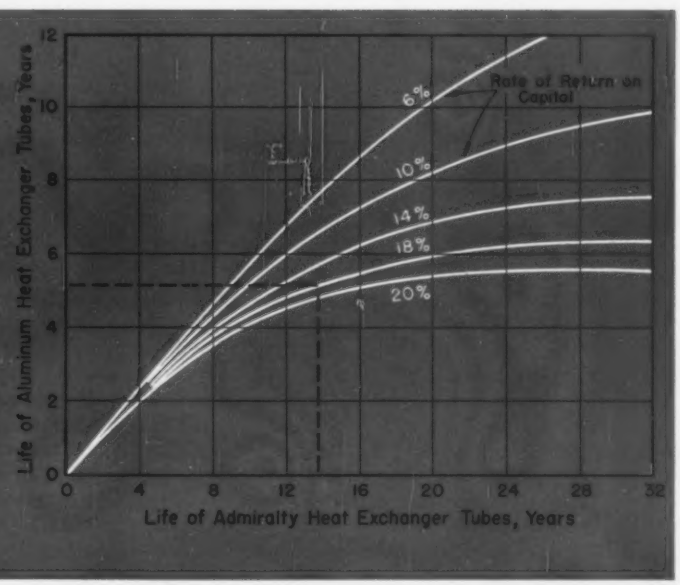

FIGURE 2—Financial break-even time for aluminum and brass tubes. Note after 5-6 years it's difficult to justify brass.

AN API SPECIAL REPORT
Aluminum Bundles

Where to Use Aluminum. The Sinclair Refining Company has found a number of applications for it. One refinery now has 27 aluminum bundles in service. Four have been in service over 6 years in a fluid catalytic cracking unit, 14 have been in service more than 5½ years in a catalytic reformer, and one has been in service over 8 years in a diethanolamine (DEA) polymerization feed treating unit. A number of these bundles have never been pulled for inspection and have had only minor cleaning on the water side. Another refinery recently retired an aluminum condenser bundle that was in operation for over 4 years in hydrogen sulfide-ammonia stripping service where steel tubes failed within 20 weeks or less, admiralty tubes failed in 5½ weeks, and 5 percent chromium (Cr) tubes failed in 17½ weeks.

Aluminum is not the highly unpredictable metal some people believe it to be. There are some locations where it will serve successfully, and there are a few locations where we know it will fail rapidly. The purpose of this paper is to aid in distinguishing between the two and to show the economic justification for trying aluminum in marginal-service locations.

Aluminum tubes could be used in a great many overhead condensers and coolers which operate below 300° F. If steel tubes are unsatisfactory in such equipment because of corrosion on the cooling-water side, then the use of aluminum should at least be considered before more expensive alloy tubes are bought. Most cooling waters treated with phosphates or chromates are satisfactory for aluminum and, where concentrations of chlorides do not exceed 50 ppm on the hydrocarbon side, aluminum has a good chance of giving successful service. Aluminum is recommended for service in the following locations:

Fluid Units. Chloride concentrations are low in fluid units, and almost any OH condenser or cooler that operates below 300° F is a likely candidate for aluminum tubes. The material stands up well in concentrations of H_2S and NH_3 which are present in fluid unit streams, as evidenced by the successful use of aluminum commingler condensers.

H_2S Removal Equipment, Amine Stripper OH Condensers, Amine Exchangers, and Amine Coolers: Articles published in trade journals[3,4] report successful service with aluminum tubes in DEA, monoethanolamine (MEA), and glycol-amine (GA) solutions where other metals were unsatisfactory. Cases 2 and 6 describe successful uses.

H_2S-NH_3 Stripper OH Condensers. Two refineries operate sour-water strippers for pollution control and have found aluminum satisfactory. A typical analysis of foul water to one stripper shows approximately 3,200 ppm sulfides, 2,500 ppm NH_3, 550 ppm phenols, and a pH of 8.5

Methylethyl Ketone (MEK Plant OH Condensers and Coolers. Aluminum is widely used in the manufacture of methylethyl ketone and should give good service in solvent refining of lubrication oils.

Light-Hydrocarbon and Petrochemical Plants. Where design pressures are not excessive, such services are "made to order" for aluminum. Temperatures usually are reasonably low, as are concentrations of chlorides and other corrodants which would affect aluminum.

Low-Temperature Services: Aluminum does not become brittle as the temperature drops below 0° F, but rather becomes stronger and more useful. In many new low-temperature processes now being developed, the metal should find wide application.

Where Not to Use Aluminum. Hydrochloric Acid and Chloride Salts Are Present. Salts in crude oil break down to form hydrogen chloride, and will cause rapid corrosion of aluminum in crude oil processing unit condensers and coolers. Because ammonium chloride is corrosive to aluminum, so neutralization with NH_3 does not completely eliminate the problem.

Sodium chloride is relatively harmless to aluminum, and relatively large concentrations of calcium and magnesium chlorides can be withstood. These salts, however, do not vaporize or come overhead, as such, in fractionating equipment. Any chloride in an OH stream is likely to be present as dilute hydrochloric acid or as iron chloride from acid attack on piping. Either of these chlorides will cause a smooth type of corrosion on aluminum and, if H_2S is present along with them, a pitting type of attack will occur.

Presence of Caustic. Where NaOH is present, attack on aluminum will be rapid.

Presence of Heavy Metals. Where heavy metals, such as mercury, copper,[2] cobalt, nickel, or lead, are present as compounds pitting of aluminum will occur. California crude oils, for instance, are known to contain traces of mercury. Other crude oils also could contain the metal.

Galvanic Action. Where there is galvanic action caused by coupling aluminum with brass, copper, lead, monel, and the like, pitting and loss of the aluminum will occur.

Aluminum Bundles. Clad tubes meeting ASTM B 210-M1A specification are rolled into aluminum tube sheets in all cases, and aluminum tie rods and baffles are used. Water flows inside the tubes. Other refiners[5] who have used existing steel or brass skeletons and retubed them with aluminum tubes encountered bimetallic corrosion, whereas all-aluminum replacement bundles were satisfactory.

Aluminum floating heads are preferred, but usually steel floating heads have been used because they were

TABLE 1—Comparative Cost of Aluminum Tubes

MATERIAL	February 1959 Base Cost (Does Not Include Freight or Extras)	
	Cost Per Tube 1 Inch By 12 Gage By 16 Feet (Dollars)	Relative Cost To Steel (Dollars)
Carbon Steel	4.14	As 1.00
Aluminum, Type 3003 Clad	5.60	1.35
1¼ percent chromium, A-213 Gr T-11	7.62	1.84
5 percent chromium, A-213 Gr T-5	10.17	2.46
Admiralty	11.87	2.86
Red brass	12.15	2.93
7 percent chromium, A-213 Gr T-7	11.47	2.77
9 percent chromium, A-213 Gr T-9	14.62	3.53
12 percent chromium, Type 410	26.19	6.31
18-8 stainless, Type 304	30.97	7.48

TABLE 2—Aluminum Exchangers in Service

Item No.	Refinery Location	No. of Bundles	Service	Operating Conditions: Temperature, Oil In (Degrees Fahrenheit)	Operating Conditions: Pressure, Oil Side (Pounds Per Square Inch)	Date Installed	Years In Service
1	Eastern Seaboard	4	Commingler condenser	150	150	1–54	4½ and 6
2	Eastern Seaboard	1	Spare commingler condenser	150	150	8–49	6½
3	Eastern Seaboard	1	H_2S-NH_3 stripper OH condenser	225	5	1951	2 before repairs
4	Eastern Seaboard	1	H_2S-DEA condenser	224	25	10–51	8½
5	Eastern Seaboard	1	HCF bottoms (gasoline) cooler	195	115	9–54	5½
6	Eastern Seaboard	2	LEF* OH (gasoline) condenser	217	47	9–54	5½
7	Eastern Seaboard	1	LEF* gasoline aftercooler	135	390	9–54	5½
8	Eastern Seaboard	2	HCF (gasoline) OH condenser	250	5	9–54	5½
9	Eastern Seaboard	2	HCF (gasoline) OH condenser	175	5	9–54	5½
10	Eastern Seaboard	1	Solvent stripper bottoms cooler	290	145	9–54	5½
11	Eastern Seaboard	1	Solvent fractionator OH condenser	380	3	9–54	5½
12	Eastern Seaboard	1	Solvent stripper OH condenser	315	10	9–54	5½
13	Eastern Seaboard	1	Depropanizer bottoms (gasoline) aftercooler	150	225	9–54	5½
14	Eastern Seaboard	2	Depropanizer reflux (gasoline) precondenser	110	300	9–54	5½
15	Eastern Seaboard	1	GA reflux condenser	230	10	9–54	5½
16	Eastern Seaboard	1	HDS stripper (No. 2 fuel) OH condenser	330	15	12–55	2 before repairs
17	Eastern Seaboard	1	Reformer fractionator OH (gasoline) condenser	195	10	5–58	2
18	Eastern Seaboard	1	Reformer fractionator (gasoline) cooler	120	65	5–58	2
19	Eastern Seaboard	1	Reformer fractionator bottoms (gasoline) cooler	200	85	5–58	2
20	Eastern Seaboard	1	HDS-DEA regenerator OH condenser	220	10	12–55	4½
21	Eastern Seaboard	1	HDS-lean DEA cooler	150	12	12–55	4½
22	Eastern Seaboard	1	C_3 splitter bottoms cooler	125	245	1–58	2
23	Great Lakes Area	1	H_2S-NH_3 stripper OH condenser	245	17	11–52	3 before repairs
24	Great Lakes Area	1	Lube HF stripper OH condenser	400	10	5–57	3
25	Great Lakes Area	1	Charge mix cooler	200	240	12–58	1½
26	Great Lakes Area	1	PO-LP† flash solvent condenser	208	4	12–58	1½
27	Great Lakes Area	1	Stripped solvent condenser	220	4	12–58	1½
28	Great Lakes Area	1	Ketone stripper OH condenser	164	4	12–58	1½
29	Great Lakes Area	1	PO-HP‡ flash solvent cooler	220	25	12–58	1½
30	Great Lakes Area	1	Propane condenser	170	180	12–58	1½
31	Great Lakes Area	1	Vacuum fractionator OH condenser	325	Vacuum	12–58	1½
32	Southern Gulf Coast	1	LEF* OH (gasoline) condenser	225	44	3–58	2
33	Southern Gulf Coast	1	LEF* bottoms (gasoline) cooler	155	372	3–58	2
34	Southern Gulf Coast	1	Fat oil (gasoline) cooler	150	350	3–58	2
35	Southern Gulf Coast	1	Reformate stabilizer reflux (gasoline) condenser	184	305	3–58	2
36	Southern Gulf Coast	1	Reformate stabilizer bottoms (gasoline) cooler	155	300	3–58	2
37	Southern Gulf Coast	1	Reformer fractionator OH (gasoline) condenser	190	5	4–58	2
38	Gulf Coast	2	Reformer fractionator OH (gasoline) condenser	190	5	5–58	7-58 baffle cut tubes
39	Gulf Coast	1	Reformer fractionator bottoms (gasoline) cooler	205	85	5–58	2
40	Gulf Coast	1	SR HDS stripper OH condenser	330	15	10–57	Replaced 2-58, bimetal
41	Gulf Coast	1	LCO stripper OH condenser	330	15	10–57	Replaced 3-59
42	Gulf Coast	2	GA regenerator feed bottoms exchanger‡	310	15	10–57	2½
43	Gulf Coast	1	GA regenerator OH condenser	230	13	10–57	2½
44	Gulf Coast	1	GA regenerator bottoms cooler	155	12	10–57	2½
45	Gulf Coast	1	Fluid depropanizer OH condenser	125	290	5–58	Replaced 2-59

* Light-ends fractionator.
† Pressed oil—low pressure.
‡ Pressed oil—high pressure.
‡ Type 3003 aluminum tubes; all others have Type 3003 clad tubes.

easier to obtain. Steel exchanger shells, shell covers, and channel heads have been used in most cases as a matter of economy, but where corrosion on steel shells has been severe, aluminum exchanger shells, shell covers, and channels have been employed.

Cladding used inside the tubes and on tube sheets is Type 7072 (72-S) aluminum alloy which contains 1 percent zinc. The cladding is highly anodic to Type 3003 (3-S) base metal and, thus, cathodically will protect it until practically all the cladding is gone from the tube. It has been explained that this galvanic action retards attack by traces of chlorides, copper, and other heavy metals in the cooling water. It also retards scale deposits in the tubes and prevents deposits, which do form, from becoming very hard. This action on scale is the same as we have noted with impressed current anodes in other water-cooled equipment and, apparently, it works in the aluminum tubes. One refinery has found it unnecessary to do more than wash the tubes with a high-pressure air-water lance during downtime.

Figure 1 shows how costs vary for complete shell and tube exchangers as purchased new. The information is for typical exchangers with steel shells of 150-pound pressure rating and pull-through floating-head design, but with bundles of various alloys.

The financial break-even time for aluminum and brass tubes is shown in Figure 2. Material costs, labor, scrap value, and interest rates are taken into account in the make-up of these curves. If a return of 18 percent is considered desirable on money invested in new refining equipment, note that during the first 3 or 4 years material costs are the governing factor, but if aluminum will last 5 or 6 years, interest rates begin to take over and make it almost impossible to justify extra money for brass.

HISTORY OF ALUMINUM BUNDLES

An East Coast Refinery—29 Bundles. Use of aluminum condenser tubes was started in this refinery. Brackish Delaware River water is used for cooling purposes on a once-through basis. It is given no treatment other than chlorination for control of marine life, but has proved to be of comparatively good quality. Generally, steel is unsatisfactory in this water, but brass and aluminum give good service.

Case 1. Five Fluid Unit Commingler Condenser Bundles. Unexpected oil-side corrosion difficulties encountered with the commingler condensers in a fluid catalytic cracking unit caused red-brass tubes to fail in about two months' time. The hydrocarbon stream contained quantities of H_2S, NH_3, water, and cyanides which did not attack replacement steel tube bundles, but these corroded and fouled so rapidly in the brack-

ish Delaware River cooling water they were unsatisfactory. For that reason an aluminum bundle employing Type 3003 clad tubes was installed in August of 1949.

After nine months of service, an aluminum tube was removed from the bundle and split open for inspection.

FIGURE 3—Tube thinned to failure at baffle location. There was minor attack on the water side and tube retained over 75 percent of its thickness 1 inch away from baffle.

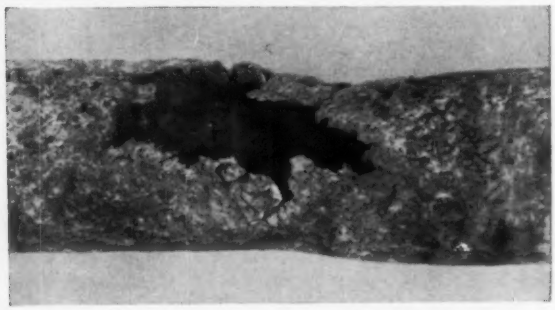

FIGURE 4—Salt deposits caused this condenser tube failure.

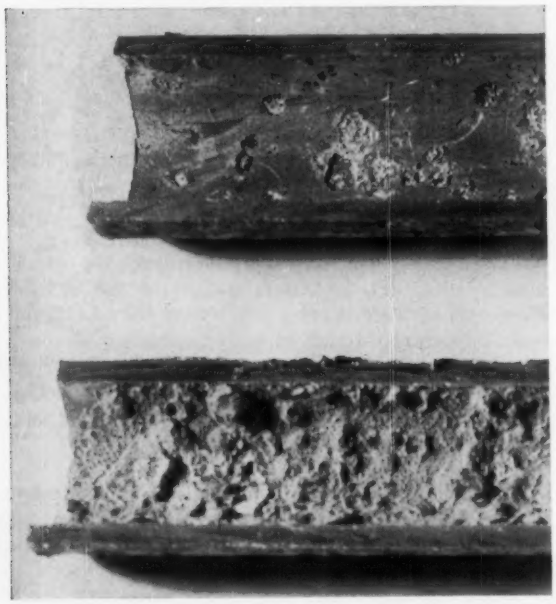

FIGURE 5—Tube section one foot from hole in Figure 4. Bottom tube shows water scale, top shows pits with scale removed.

The cladding was pitted all the way down to the base metal in places, and approximately 10 percent of the total cladding was gone. The bundle was returned to service and a second tube was removed for inspection after about 18 months of onstream time. The second tube showed only a little more loss of cladding than the first one. The tube supplier advised that it was normal for pitting of the cladding to proceed rapidly at first and then slow down as the time period was extended.

In January of 1954, four new aluminum bundles were installed in the commingler condensers, with the original bundle removed but retained as a spare. After approximately 4½ years of service, these tubes showed a considerable amount of the cladding in place and appeared in fair condition.

Two of the four new bundles are still in use after six years' service. One failed in August of 1958 after slightly more than 4½ years (39,008 stream hours) of operation. Tubes in that bundle showed moderate to heavy pitting on the bottom side of the tubes near the shell inlet. Most severe pitting occurred where the tubes enter the first two vertical baffles. The leaking tube was in the middle of the bundle, and the hole was at the second baffle. Failure appeared to have been caused from a combination of localized iron sulfide and impingement attack. Tube specimens sent to the supplier were reported to have 5.4 micrograms of mercury present per square inch of surface. At the time of failure a companion bundle was pulled for inspection, but corrosion on this bundle did not appear serious. A second bundle was replaced in January of 1960 (50,744 stream hours) because of relatively deep and scattered pitting.

Case 2. DEA Regenerator OH Condenser. Because of the early success in Case 1, an aluminum bundle was ordered for a DEA regenerator OH stream in an H_2S removal unit on polymerization plant feed. A brass bundle had been used originally for this service but leaked after 10 months' service. The brass tubes were badly attacked on the process side and a subsequent analysis of the OH condensate showed 0.15 percent NH_3 content. A steel bundle replaced the brass one, but it also failed after approximately 10 months' service. The failure was caused by H_2S attack.

In Ocober 1951, the new aluminum bundle was installed. Inspection after four years of service showed the bundle was still in good condition with only typical water corrosion of the Type 7072 clad lining inside the tubes, and no apparent corrosion on the outside of the tubes (process side). This bundle was cleaned once on the water side in 1955. At the last inspection, in January of 1958, tubes had the typical pitting which occurs on the water side with Type 7072 cladding; other than that, they were in good condition. Service life now exceeds 8½ years.

Case 3. Sour-Water Stripper OH Condenser. Process water from the fluid catalytic cracking unit and other sources is steam stripped of H_2S and NH_3 before going to disposal. Originally an all-steel condenser was used for this service, but the bundle failed in two months as a result of corrosion on the foul-water side. In 1951 a complete aluminum bundle and shell were installed. The bundle was first retubed in 1953 after two years

of satisfactory service and has since been retubed in 1954, 1956, and 1958 because of failure from the foul-water side. The last two failures were caused by corrosion at the ends of the tie rod spacers, which allowed the vertical baffles to vibrate and cut into the tubes to a point where leaks occurred.

In May of 1958, repairs to the bottom half of the condenser shell also were required because of cutting by the vibrating vertical baffle of the tube bundle. In 1954 an aluminum reflux accumulator was placed in service following this condenser.

Case 4. Fifteen Bundles in a Catalytic Reformer. In September of 1954, a new catalytic reformer went on-stream and 15 aluminum bundles were put into use. Services are listed in Table 2, see Item No. 5 through No. 15. These bundles are still in operation after 5½ years with no repairs required to any of them. During this period of operation, only a few of the bundles have been pulled for inspection, although most have been cleaned at least once on the water side with an air-water lance.

Case 5. Hydrodesulfurizer (HDS) Stripper OH Condenser. The condenser was put into service in December of 1955. Hydrocarbon inlet temperature was 330° F, the process stream contained up to 2.5 percent H_2S, stripping steam, some NH_3, and traces of chlorides. Off-water averaged about 7.5 pH. The bundle developed a leak after 27 months of service. Tubes and baffles were severely pitted on the process side 3 feet to 5 feet back from the hydrocarbon inlet. Some grey deposits were found in this area, but the remainder of the bundle was relatively clean and free of attack. X-ray diffraction tests on tube samples showed traces of zinc, copper, chromium, vanadium, and large quantities of iron compounds to be present.

A new aluminum bundle was installed and when inspected in August of 1958, after 5 months of service, it also showed mild pitting near the hydrocarbon inlet. A theory that iron sulfide scale from the piping could have caused the attack led to installation of an inhibitor system. Continuous injection of 10 ppm of an organic film forming an amine type of corrosion inhibitor has been used since that time. When the bundle was again inspected after an additional eight months, the inhibitor seemed to have considerably retarded the corrosion, and metal loss was about the same as in August of 1958. One fairly deep pit was found, and as a matter of precaution that tube was plugged off. To date, the bundle is still in service.

Case 6. Six Bundles in Various Services. Four bundles in gasoline cooler or condenser service installed in 1958 are listed in Table 2, Item No. 17 through No. 22. In 1955, two other bundles were installed in an H_2S removal unit employing DEA. These bundles are still in service and the only maintenance to date has been minor cleaning on the water side.

A Refinery in the Great Lakes Area—9 Bundles. Success with aluminum in the East Coast refinery led to a trial of the material in the Great Lakes area. Lake Michigan water in closed cooling-tower systems is maintained at good quality by polyphosphate treatment and supplemental chlorination. Steel tubes give 2 to 4 years' life in this water and brass stands up very well.

Case 7. Sour Water Stripper OH Condenser. Water from the fluid catalytic cracking process streams is steam stripped of H_2S (3,200 ppm) and NH_3 (2,500 ppm) as an antipollution measure before disposal. Service was started in November of 1950 with an all-steel OH condenser. Corrosion rates on the steel tubes and shell were excessive, the longest life being 20 weeks on a set of steel tubes, with an organic amine type of corrosion inhibitor being fed batchwise at least part of the time, and repairs made once. The shortest life on steel was 5½weeks. A set of admiralty tubes lasted less than 1½ weeks, and a 5 percent Cr tube bundle gave 17½ weeks of service with the inhibitor being fed at least part of the time. The shell was replaced once after corroding and leaking developed. Only minor corrosion occurred on the cooling-water side.

After the East Coast refinery reported good results with aluminum, an all-aluminum shell and tube bundle were installed. Steel bolts held the aluminum floating head to the aluminum tube sheet. Because of corrosion, these bolts failed in slightly less than six months, and were replaced with 18-8 stainless steel bolts, Type 304. Within nine months, the 18-8 bolts failed because of a galvanic attack, and again, allowed a leak in the floating-head gasket. As aluminum bolts were not available, 18-8 bolts were reinstalled and lasted only eight months when galvanic corrosion caused their replacement with aluminum. These aluminum bolts have been satisfactory, as they showed no corrosive attack when inspected after 20 months' operation and, at the present time, they are still in service. Stretching caused by overtightening is a minor problem and must be avoided.

The first set of Type 3003 clad tubes failed because of external corrosion and thinning at the baffles, see Figure 3, after 10,461 stream hours, or 14½ months of service. The second set of Type 3003 clad tubes showed heavy external corrosion when inspected after 19,765 stream hours, or 27 months of service. They were leaking somewhat when replaced about the middle of August 1958, or 53 calendar months after installation.

Corrosion on the water side of the tubes has consisted of light general pitting of the clad surface and some loss (approximately 10 percent) of the cladding from the water side of the tube sheet. No corrosion inhibitor has been introduced into this unit since the installation of the aluminum tubes.

Case 8. One Bundle in a Lube Hydrofinisher—7 in an MEK Plant. Item No. 24 through No. 31 in Table 2 indicate one bundle installed in 1957 to condense vapors containing H_2S in a Lube Hydrofinishing unit and seven bundles in various services at a new MEK lube processing unit. The latter was placed in service in December of 1958. No maintenance other than cleaning of the water side with an air-water lance has been required on any of the bundles to date.

A Southern Gulf Coast Refinery—6 Bundles. Success with aluminum bundles in the catalytic reformer

unit, see Case 4, led to the installation of six bundles in various locations when a new reformer was built in this southern Gulf Coast refinery. Services are shown as Item No. 32 through No. 37 in Table 2. Purchased city water is used in a closed cooling-tower system. This water was treated with polyphosphates for the first month the unit was in operation, then a change was made to the chromate-phosphate dianodic type of treatment. Chlorination is used for algae control. No desalter is used in this refinery, however, salt content of the crude oil is normally low.

Case 9. Reformer Feed Fractionator OH Condenser. The unit was placed onstream in March of 1958 and operated smoothly until the OH condenser bundle failed in December after 6,953 hours. As shown in Figure 4, corrosive attack on the tubes had occured under salt deposits that were built up in the bottom section of the bundle just back of the hydrocarbon inlet for a distance of 3 to 5 feet. Tie rods and baffles in this area were severely corroded, but the rest of the bundle was fairly clean and free of corrosive attack. Figure 5 shows some loss of cladding from inside the tubes also had occurred where water-side deposits were built up. These deposits are believed to have been residual phosphates left in the water system when the change was made from glassy phosphate treatment to chromate water treatment approximately 30 days after the unit went onstream. Fifty-nine tubes were renewed and the bundle was put aside as a spare.

Water drawn from the OH receiver, prior to the tube failure, showed an average analysis of 0.3 ppm aluminum (Al), 0.8 ppm iron (Fe), 128 ppm chlorine (Cl), and 8.0 pH. The tube supplier reported trace quantities of mercury to be present in sludge from the bundle and 15 to 20 micrograms of mercury present in the scrapings from 2 square inches of the surface of tubes and tie rods, respectively.

A new spare bundle was installed, and shortly thereafter a water-wash system was hooked up to continuously inject 3.1 gph of boiler feedwater (10pH and containing approximately 75 ppm of chlorides) just ahead of the condenser. Water drawn from the OH accumulator averaged 1.8 ppm Al, 2.2 ppm Fe, 71 ppm Cl, and 6.8 pH. A stressed brass strip was cracked in 10 days' time in a sample of this water heated in the laboratory. The bundle was pulled for inspection in April of 1959. The outside diameter (OD) of the tubes showed considerable metal loss in the inlet area caused by a smooth impingement type of attack, and some pitting had occurred throughout the bundle. Very little salt deposit was found in the bottom of the bundle on this occasion. The interior of the tubes was smooth and clean with only an occasional small pit in the cladding. This further indicated loss of cladding, from inside the tubes of the first bundle, was caused by a deposit of residual phosphates used in the earlier water treatment.

The repaired original bundle was reinstalled at this time and steam condensate injection was substituted for boiler feedwater. The steam condensate averaged

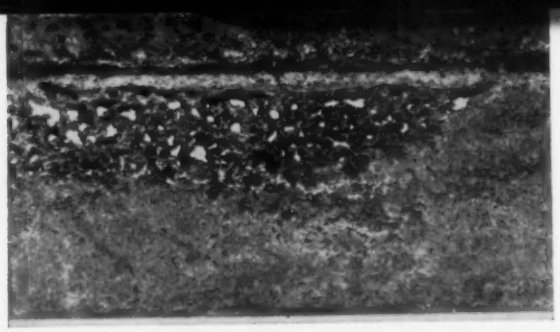

FIGURE 6—The spacer baffle at the vapor inlet was perforated because of salt deposits.

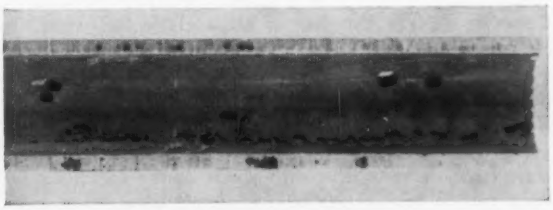

FIGURE 7—Pits originating on the water side caused failure; boiling under vacuum conditions possibly responsible.

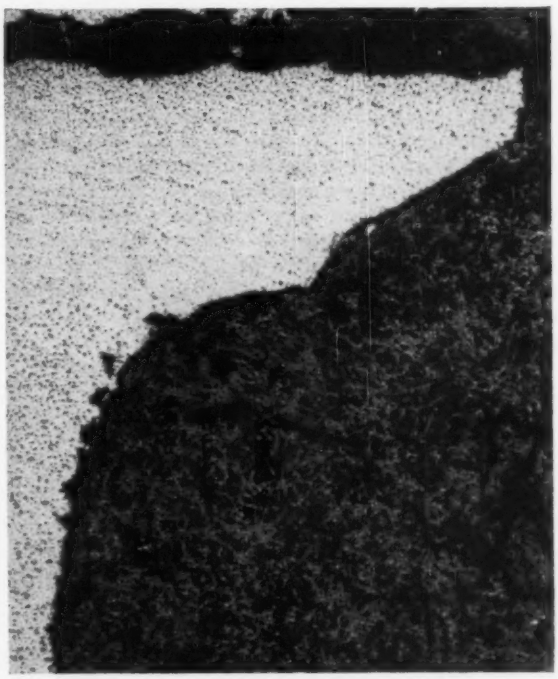

FIGURE 8—Pits mushroomed under the surface giving a hollowed-out effect.

3 ppm chlorides and about 5.5 pH because of dissolved CO_2. Tests on accumulator water thereafter averaged 1.2 ppm Al, 1.3 ppm Fe, 33.2 ppm Cl, and 7.0 pH. This bundle is still in service.

Case 10. Reformate Stabilizer OH Condenser. This condenser was placed in service in March of 1958. When the bundle was pulled for inspection in March of 1959, the outside surface of the tubes and baffles showed pitting and etching in the first half of the condenser to a point where replacement was necessary. Quantities of

white deposits were found on the tubes and baffles. The interior of the tubes showed some loss of cladding because of a buildup of phosphate deposits, much the same as shown in Figure 5. A new spare aluminum bundle, which was installed with a condensate water wash added ahead of it, is still in service.

Case 11. Four Bundles in Various Reformer Service. The bundles shown as Item No. 33 through No. 36, in Table 2, have been in service over two years but have required no maintenance to date.

A Gulf Coast Refinery—10 Bundles. The first 6 aluminum bundles went into operation in this refinery in 1957 when two new HDS units with an auxiliary GA system were placed in service at the same time in October 1957. Aluminum was chosen for its resistance to H_2S and its resistance to corrosion in GA solutions. Cooling water in closed cooling-tower systems comes mainly from a local river. The water is first passed through clarifiers where alum is used to reduce turbidity. Over the past years, most cooling systems have been treated with glassy phosphates, but some chromate-phosphate dianodic treatment was used in 1959, and one "dirty water" system containing oil from vacuum jets received little treatment.

Case 12. Straight-Run Naphtha HDS Unit—Stripper OH Condenser. The stripper OH condenser developed a leak in February of 1958, approximately four months after it went into service. Aluminum baffles near the hydrocarbon inlet were corroded to failure, as shown in Figure 6, but corrosion on the outside of the tubes was minor, and baffles 5 feet from the inlet showed very little attack. Tubes were removed from the bundle and split open. They were found to be severely pitted from the water side, directly under the hydrocarbon inlet as shown in Figure 7. Pits were small at the surface, but mushroomed to considerable size once under the surface, thus giving a hollowed-out effect which may be noted in Figure 8. Pitting stopped abruptly about 3 feet from the hydrocarbon inlet, some smooth loss of cladding was apparent for the next few inches, and then tubercular deposits of water-treating chemicals appeared, continuing to the cold end of the tube. Some loss of cladding was apparent under deposits. There were no deposits in the hot area where failure had occurred, only a thin, tightly adherent brown film that protected the tubes beautifully where it was unbroken. Cooling water for this bundle was from a dirty water cooling-tower system and received little treatment other than addition of H_2SO_4 to maintain pH at about 7.5.

Appearance of the tubes led to the speculation that cooling water had been boiling in the area of the hydrocarbon inlet. Flow arrangement is such that the hottest water in the bundle is leaving tubes located directly beneath the hydrocarbon inlet. The hydrocarbons enter at 335° F and the water, theoretically, should be leaving at approximately 112° F. The bundle, however, is located on a two-story structure about 23 feet above ground level and the cooling water flows from it to an underground line, thence by gravity to a cooling-tower basin. This arrangement allowed a siphoning action to occur, and it was later shown that a small water-sampling line near the exchanger drew in air when its valve was opened. This means the water in the exchanger was under a slight vacuum at the hot or outlet end and could boil at somewhat less than 212° F.

A spare bimetallic tube bundle was installed, the water outlet valve at the exchanger was partially closed until water flowed from the sampling line, and the unit was returned to service. Subsequent tests in the tube supplier's laboratory showed small quantities of mercury to be present in pits on the water side of the tubes, and refinery tests showed chlorides, up to 300 ppm, to be present in the hydrocarbon stream. It is very probable that aluminum would have proved unsatisfactory in this service even if low-pressure boiling had not occured.

Case 13. Light Cycle Oil HDS Unit—Stripper OH Condenser. This condenser on the companion HDS unit was inspected in February of 1958 but was not leaking. Water pressure apparently had been sufficiently high to prevent boiling in the tubes, and pitting was not as severe as in the straight-run stripper OH condenser, see Case 12. Furthermore, pitting on the baffles was not nearly as severe, probably because the chloride content of the process stream was lower. The bundle was returned to service and was operated with a raised water pressure until September of 1959. At that time, corrosion of the floating-head gasket surface allowed a leak to occur and the bundle was replaced with a bimetal tube spare.

Case 14. GA Regenerator Feed to Bottoms Exchangers—2 Bundles. Hot GA from the bottom of the regenerator tower is cooled before being pumped back to the contact tower to again absorb H_2S from the hydrogen stream. The hot "lean" GA gives up a great deal of its heat in this pair of exchangers to cold "rich" GA on its way to the regeneration tower. These are the only exchangers in the system which employ Type 3003 aluminum tubes instead of Type 3003 clad tubes. Cladding was not used because these exchangers are not contacted by cooling water. Bundles have not been inspected since they went into service. Following the discovery of chlorides in the GA solution and pitting of other aluminum bundles in the system, it is anticipated that these bundles will be run to failure and replaced with another material.

Case 15. GA Regenerator OH Condenser. An OH stream from the regeneration tower containing H_2S, water vapor, a small amount of MEA, and some chlorides picked up by the process stream is passed over this bundle. Condensate containing up to 200 ppm chlorides is either returned to the system or discarded.

When inspected May 5, 1958, approximately 10 percent of the cladding was gone from the tube sheets and from inside the tubes. The outer surface of the tubes at the hot-vapor inlet showed a smooth general loss of metal, estimated to be 25 percent of the tube thickness. The bundle will be run to failure and replaced with a different material.

Case 16. GA Regenerator Bottoms Cooler. Lean GA which has been reduced in temperature by its passage through the feed bottoms exchangers is further cooled in this bundle. When inspected in May of 1958, about 10 percent or more of the cladding was gone from the tubes and tube sheets on the cooling-water side. Also, some tuberculation was noted on the GA side of the

tubes, and when this was scraped away pits which were long and narrow in form were discovered, extending approximately 0.010 inch into the metal. Either the cooling-water attack or the process-side attack alone might be bearable, but it is doubtful aluminum will be acceptable when attacked from both sides. It is anticipated the bundle will be run to failure and then replaced with another material.

Case 17. Fluid Catalytic Cracking Unit—Depropanizer OH Condenser. Four OH condensers in this service, arranged in two parallel banks of two each, were originally equipped with bimetallic tubes, admiralty on the inside, steel on the outside, both 17 gage. Corrosion from the hydrocarbon, or shell side of the exchangers caused general thinning of the outer steel tube until the admiralty was exposed. Rapid pitting of the admiralty ensued, and failure of bundles began to occur after approximately 18 months. Inhibitors helped very little, and all bundles failed within 30 months or less. The hydrocarbon stream contains H_2S, NH_3, and some water. An aluminum bundle was installed April 29, 1958, in one of the bottom (coldest) shells for test purposes. The channel cover was pulled for inspection after 25 days, at which time tubercular deposits from the cooling water were found in the tubes and on the tube sheet. This was phosphate-treated water from a closed-circuit cooling tower. When deposits were scraped away, some pitting of the cladding was evident. The bundle was returned to service until February 27, 1959, at which time it was removed because a large concentration of water deposits had built up inside the tubes. No attack was found on the hydrocarbon side. A spare bimetal tube bundle was reinstalled.

Case 18. Reformate Fractionator OH Condensers—2 Bundles. Two bundles in series were installed in new equipment which was put into service May 11, 1958. The coolant was phosphate-treated water from a new closed-circuit cooling tower. On July 21, 1958, a leak occurred in the top bundle and three tubes were found to be severely cut at one baffle location because of vibration. Some tuberculation on the water side and some pitting of the cladding on both tubes and tube sheets were found. A spare aluminum bundle with vibration dampers was installed and, at the present time, is still in service. A chromate type of cooling-water treatment was started in March 1959, but when both bundles were inspected in May of 1959, considerable residual phosphate scale was found inside the tubes. The bottom bundle was replaced with the spare bundle containing three repaired tubes. No attack was noted on the hydrocarbon side.

An aluminum reformate fractionator bottoms cooler has not been inspected since it was installed in May of 1958.

Precautions. Where contamination with chlorides, heavy metals, or both, inadvertently exceeded the maximum recommended by the supplier, corrosion has occurred and unsatisfactory service has resulted. Bundles that are corroding will be run to failure and their service life evaluated against the life possible from other materials. In some cases, reduction in concentrations of contaminants or use of corrosion inhibitors may prove the most practical course. In the case of the H_2S-NH_3 strippers, a service life of 2 to 4 years with aluminum is considered to be quite good, although 6 to 8 years is considered the minimum acceptable for general refinery service, and 10 years is the desired service life for an exchanger bundle.

We find, that our simple laboratory reports which give chlorides in parts per million are not sufficient. One should also know whether the chlorides are present as stable salts, unstable salts, or HCl. Obviously these materials do not react alike.

Possible loss of circulating water caused by an interruption in electrical power is the main reason for holding operating temperature limits low on aluminum tubes. We would prefer to keep inlet temperatures below 300° F, but where operating pressures are low the temperature limit can be raised to 400° F. Equipment, normally, is designed to absorb pressures above the safety relief valve setting with no water present in the tubes and a certain amount of thinning caused by wear.

Experience has shown, that a test tube should always be installed in any cooling-water system where an aluminum bundle is being considered for the first time. Operating conditions are not always as predictable as we would like, and we believe that a few failures are bound to occur. This will be true regardless of the metal used. Aluminum is no better or no worse in this respect than the more commonly used tube materials. Certain qualifications, specific to aluminum, make it a metal which can no longer be ignored for some refinery services.

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About the Speaker

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A SPECIAL REPORT

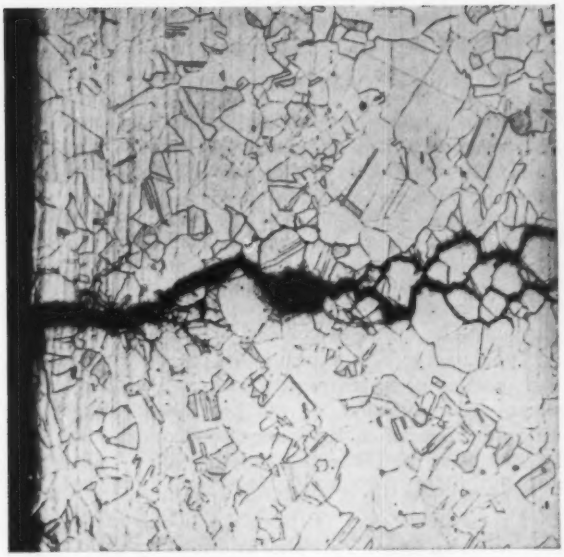

FIGURE 1—Chloride from steam cracked this Type 304 spent catalyst pipe.

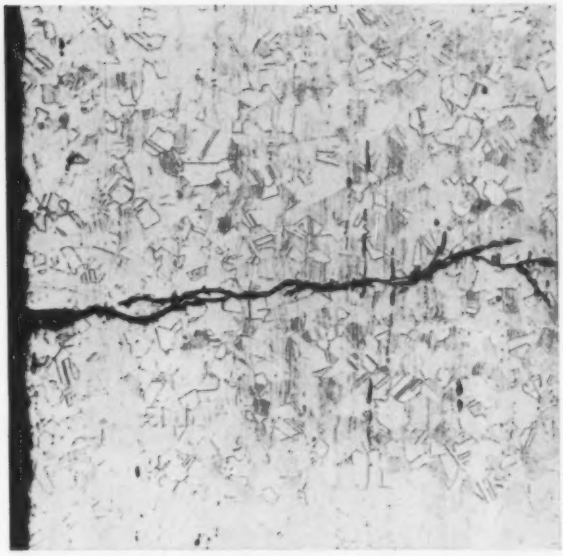

FIGURE 2—Salt water in light wax distillate cracked this 304 exchanger tube.

CORROSION SESSION

Refiners Report New Cases of Stainless Steel Failure

Stress corrosion cracking and intergranular corrosion are the main causes of stainless failures. Case histories show how to solve these problems

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Arabian American Oil Company
New York City

THE USE of stainless steels in petroleum refineries has gone through a cycle of fashion. At one time 18-8 chromium-nickel steel was looked on as a cure-all for corrosion problems; its only drawback was cost or unavailability. After many improper applications or unfortunate accidents, the fashion has changed to the point where, in some refineries, stainless steels are being removed from plants or specified only when no other material is available for the service. Both of these attitudes are extremes which can be avoided with proper knowledge of the material.

The majority of the case histories of stainless steel failures indicate that stress corrosion cracking and intergranular corrosion are the main causes of failures. As a result, methods for preventing stress corrosion cracking have been developed and are available for the proper selection and use of stainless steel.

Austenitic stainless steels are permitting increased process temperatures and pressures because they exhibit a wide range of mechanical properties and superior corrosion resistance. Proper application of stainless steels can also result in lower maintenance, operating, and replacement costs.

There are applications in which the austenitic stainless steels should not be employed. For these cases, considera-

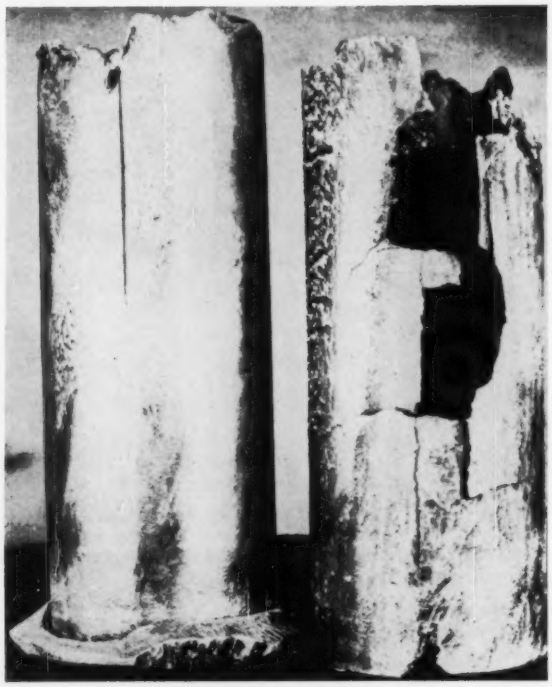

FIGURE 3—Caustic injection nozzle liner disintegrated after two weeks service.

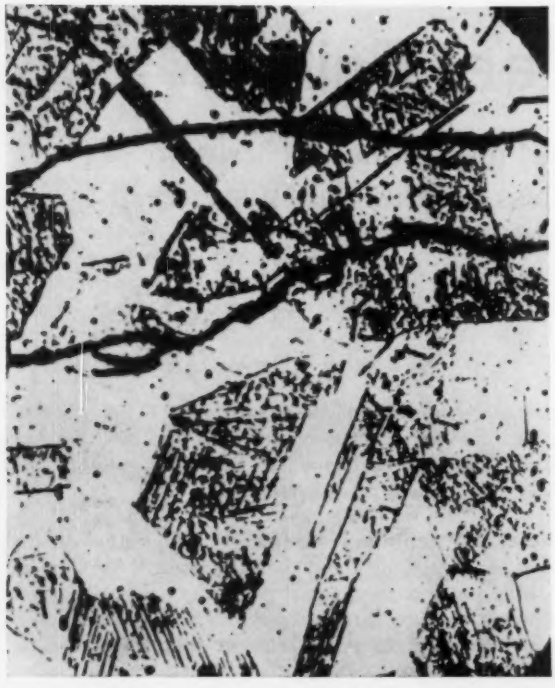

FIGURE 4—Photomicrograph of nozzle liner shows stress corrosion cracks.

tion should be given to the use of the straight chromium stainless steels which are not susceptible to stress corrosion cracking and intergranular corrosion. However, these alloys have limitations, such as lower strength, embrittlement, welding difficulties, and lower corrosion resistance.

CASE HISTORIES

(Editor's Note: The authors included several more case histories in their original paper; however they were previously reported in the technical literature.[1-7, 9, 10, 15] The case histories presented in this abstract are from previously unpublished sources.)

Case 1. Transgranular cracking was reported in Type 321 stainless steel pilot plant equipment in a deoxygenating unit. The unit was charged with platinum catalyst and operated at 200° F and 4,000 psi. Hydrogen under high partial pressure reacted with the oxygen in the stream to form water. It was postulated that, during the initial operation, chlorides and fluorides may have leached from the platinum catalyst.

Remedy: The use of a high nickel-chromium (78 Ni-15 Cr) stainless steel (B168-58T) or the use of used catalyst from other catalytic reformer operations was suggested.[8]

Case 2. A Type 304 stainless steel pipe transporting spent catalyst and steam in a catalytic reforming unit failed after two years of service. The movement of the catalyst severely eroded the internal pipe surface. Many circumferential cracks propagated transgranularly and then intergranularly through the pipe wall. Figure 1 shows the nature of the cracking. Failure was attributed to the presence of chloride-contaminated water formed from steam condensation during downtime. The tensile stress level was estimated to be on the order of 18,000 psi.

Remedy: The austenitic stainless steel pipe was replaced with a low chromium-molybdenum ferritic alloy resistant to stress corrosion cracking. This material should perform satisfactorily in this service where the operating temperature reaches a maximum of 925° F.[11]

Case 3. An austenitic stainless steel U-bend tube bundle in a heat exchanger failed at the bends while the unit was in service. The tube bundle was washed down with sea water and not thoroughly rinsed with fresh water during the cleaning operation. The presence of high residual tensile stresses, which resulted from cold bending and chlorides from the sea water, was the cause of cracking.

Remedy: All the cracked U-bends were replaced with stainless steel. The use of sea water for washing down exchangers was discontinued to prevent recurrence of a similar type of failure. The use of fresh water during cleaning operations on austenitic stainless steel equipment was made mandatory.[12]

Case 4. Several Type 304 stainless steel tubes in a floating-head heat exchanger failed after six months of operation. The unit was a desulfurizer feed-reactor

effluent exchanger which handled light wax distillate on the tube side and desulfurized product on the shell side. The tube failures which originated from the tube side were caused by stress corrosion cracking, presumably as a result of salt water in the light wax distillate feed. The path of the cracks is shown in Figure 2. The salt water probably entered the feed through tube leaks in the overhead condensers at the crude oil unit vacuum columns. Internal tensile stresses were probably produced in the cold-straightening process at the mill after the tubes were solution-annealed at 2,150° F. The unit operated at 500 psig and 725° F.

Remedy: The use of materials resistant to stress corrosion cracking, such as straight chromium Type 410 stainless steel tubes was recommended. Other considerations were the elimination of the salt-water leakage; the use of processes such as desalting, drying, or stripping to remove the salt water from the feed; and the possibility of using kerosine in place of salt water to cool the feed.[11]

Case 5. A heat exchanger constructed with austenitic stainless steel tubes failed after approximately two years of service. Fresh water was used to cool a product stream which entered at 375° F. Examination of the tube failures revealed that stress corrosion cracking occurred from the water side. Analysis of the heavy scale deposits removed from the tubes revealed that the chloride content adjacent to the tube surface was 3,000 ppm to 4,000 ppm. The cooling water contained only 50 ppm to 100 ppm of chlorides. It was believed that the stresses were attributable to fabrication, and the tube bundle used as a replacement was stress-relieved.

Remedy: The accretion of heavy scale deposits on the water side and high temperature were responsible for the concentration of chlorides. As a result, feed-product exchangers are planned, in future designs, to lower the stream temperature to 250° F maximum before cooling with fresh water. Insufficient operating time has elapsed to ascertain whether or not the stress-relieved tube bundle will prevent the recurrence of stress corrosion cracking.[13]

Caustic Solutions. Most of the case histories discussed thus far have dealt with the presence of chloride ions in the corrosive medium. Caustic solutions have the same effect on stainless steel in the presence of tensile stresses. The following case histories involving stress corrosion cracking in the presence of caustic solutions have been reported:

Case 6. An 18-8 stainless steel sheet was cold-bent and welded to form a sleeve which was inserted in a still nozzle. The liner was installed to protect the still nozzle from corrosion by a distillate at 460° F to 500° F at the location of caustic injection. The liner disintegrated after approximately two weeks in service. The condition of the liner is illustrated in Figure 3. There were no operating stresses to which the liner was subject other than the internal stresses introduced during cold bending and welding. The active corrodent was the caustic, for the oil itself was not thought to be corrosive. Examination revealed that all the cracks (see Figure 4) were transgranular, typical of stress corrosion cracking.

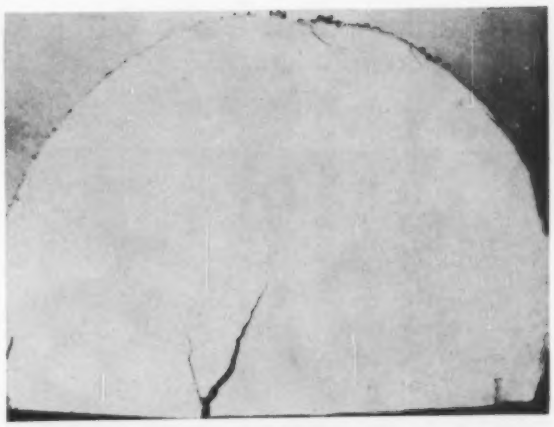

FIGURE 5—Mill stresses in 304 baffle plate caused failure in six months.

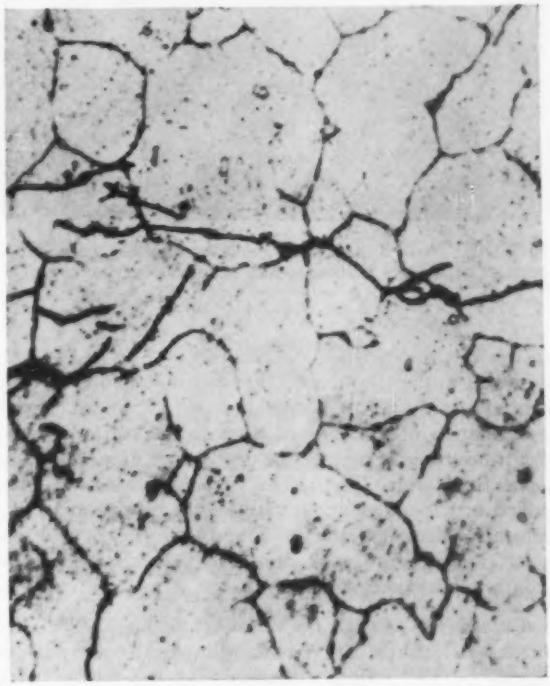

FIGURE 6—Photomicrograph of nozzle liner shows telltale stress corrosion cracks.

Remedy: A liner fabricated from nickel sheet should be used to replace the austenitic stainless steel liner, provided no sulfur is present in the system. Sulfur would attack the nickel, especially at an interface of liquid and vapor. In the event sulfur is present, a high nickel-chromium (78 Ni-15 Cr) stainless steel (B168-58T) should be used because of its resistance to hot caustic solutions in the presence of sulfur.[14]

Case 7. Two vapor outlets in an oil still were baffled with Type 304 stainless steel. The baffle in the outlet

FIGURE 7—18-8 caustic regenerator bubble caps failed because of stresses induced while cold-drawing the caps.

adjacent to the caustic injection distributor failed within six months as a result of cracking (see Figure 5). Microexamination of a section of the cracked baffle revealed the transgranular path of the cracks (see Figure 6). The plate from which the baffles were fabricated was hot-rolled at the mill without receiving a high-temperature annealing heat treatment. The presence of internal stress and concentrated caustic caused the premature failure of the baffle plates.

Remedy: A high-temperature annealing heat treatment would have eliminated the internal stresses introduced by hot rolling. Inasmuch as the baffles were welded to the nozzle wall, welding stresses would probably be introduced. Under these conditions, the use of a high nickel-chromium stainless steel (B168-58T) for the baffle material should be considered.[14]

Case 8. Complex cracking of 18-8 bubble caps (see Figure 7) occurred in a caustic regenerator. The cracks were transgranular and resulted from the presence of internal stresses caused by cold-drawing the caps. They were not annealed after drawing, as indicated by the considerable hardness in the vicinity of the cracks. The chemical attack resulted from the caustic.

Remedy: The bubble caps should have been annealed after cold drawing to eliminate the internal stresses. The outer edges of the caps which were not cold-worked did not show any sign of cracking.[14]

Intergranular Corrosion. Recognition of the causes of intergranular corrosion by stainless steel manufacturers and users has materially reduced the number of failures attributable to this phenomenon. The literature, however, contains case histories which are of interest. These failures occurred in tubes, furnace piping, vessels, and vessel linings normally found in petroleum refineries.

Case 9. Type 304 stainless steel heater tubes and transfer lines in hydrodesulfurization units failed during shutdown after the unit was cleaned with steam. The metal temperature during operation was in the chromium carbide precipitation range of 850° F to 1,550° F. The failures were attributable to the formation of polythionic acids which formed in the presence of moisture and sulfide-bearing deposits.

Remedy: The stabilized grades of stainless steels, such as Type 321 or 347, should be used for the tubes and headers when the operating metal temperatures are in the sensitizing range.

Case 10. Type 304 stainless steel tubes in a feed-product heat exchanger in a Platformer failed intergranularly after approximately two years of service. The failures occurred in an area near the inlet of the tube bundle on the shell side. Figure 8 shows a cracked tube removed from the bundle. The inlet temperature of the product was in the range of 875° F to 975° F. Examination revealed that the tubes were sensitized by the precipitation of chromium carbides along the grain boundaries. The intergranular attack, with isolation of some grains, is illustrated in Figure 9. The corrosion actually occurred during the downtime. The corrosive medium was polythionic acid which formed from a reaction between iron sulfide scale and water.

Remedy: The unit was retubed with stabilized Type 321 stainless steel tubes in order to prevent chromium carbide precipitation. No further problem of this kind is anticipated.[13]

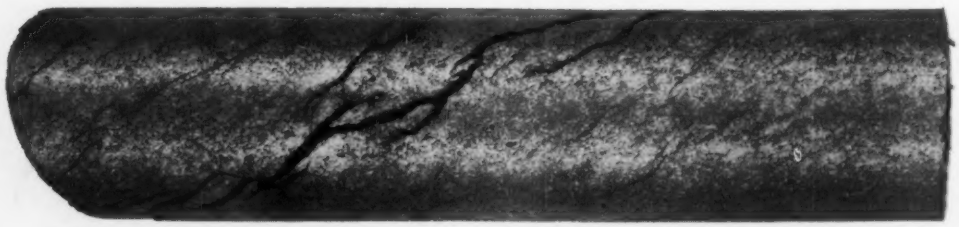

FIGURE 8—Reformer, feed-product exchanger tube, Type 304, failed after two years service

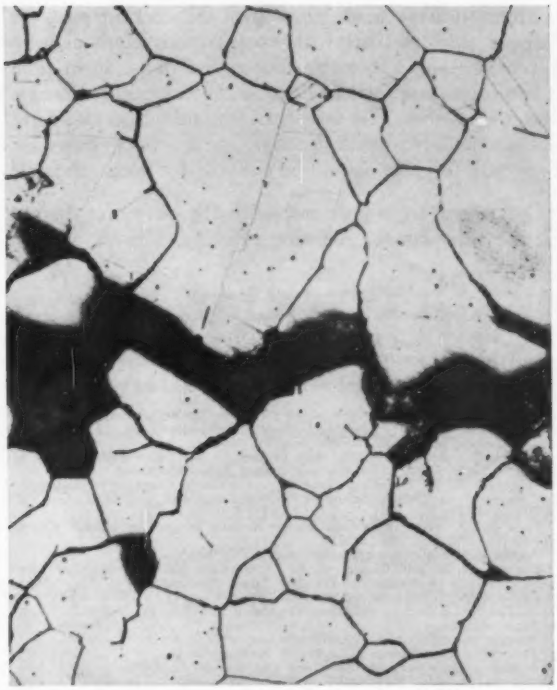

FIGURE 9—Intergranular attack of exchanger tube evidenced by chromium carbide percipitation along grain boundaries.

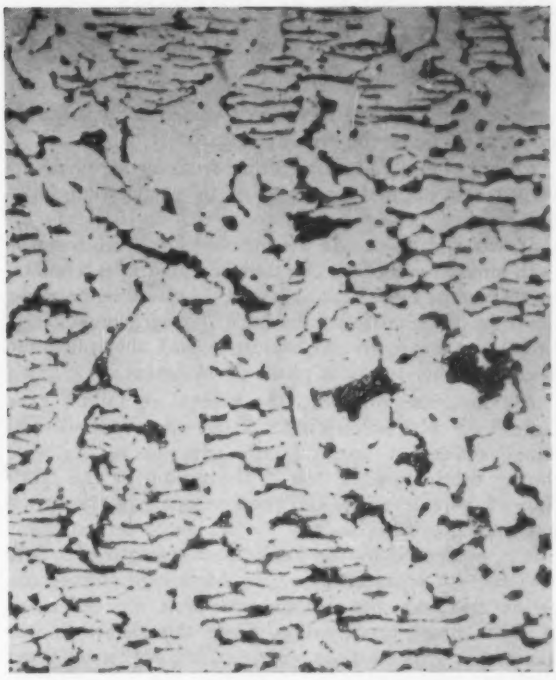

FIGURE 10—A predominance of brittle sigma phase can be seen in this Type 316 welding neck flange.

Case 11. A number of failures occurred in Type 304 stainless steel vaporized feed inlet lines to a moving-bed catalytic cracker after 18 months of operation. The lines operated in the temperature range of 950° F to 1,020° F, which is within the sensitizing range. Examination revealed that cracking occurred intergranularly. The corrosive was not definitely established, but it was believed that polythionic acid corrosion took place during a shutdown. This was based on the fact that moisture was present as a result of steaming out the lines prior to shtudown. The predominance of the attack on the bottom of the horizontal runs of the lines substantiated this belief.

Remedy: The piping was replaced with the stabilized grades Types 347 and 321 stainless steels, and after some 13 years of service no further corrosion difficulty has been encountered.[13]

Case 12. Type 304 stainless steel piping, tubing, and linings have been used successfully in diethanolamine (DEA) hydrogen sulfide removal plants. Recently a number of failures of Type 304 piping occurred in hot, reactivated amine lines between the reactivator and lean-foul solution exchangers. The temperature of the stream at this location was approximately 260° F to 270° F. Examination revealed that the intergranular cracking occurred as a result of the presence of chromium carbides along the metal grain boundaries. The history of the piping was investigated, and it was found that the fabricator had permitted the piping to cool slowly from a 1,550° F stress-relieving temperature in a furnace.

Remedy: The piping should have been stress-relieved at 1,650° F to 1,700° F and cooled more rapidly from the stress-relieving temperature. This would have prevented the formation of a sensitized structure susceptible to intergranular attack.[13]

Case 13. A number of high-pressure, cast stainless steel valves, with an analysis similar to Type 316, were placed in very dilute sulfuric acid service at a temperature of 500° F. This material was selected on the basis of corrosion tests which revealed low corrosion rates for Type 316 stainless steel. After a few months of operation, one of the valves leaked through the body casting. All of the valves were examined and found to be severely corroded intergranularly. The castings were received in a sensitized condition which resulted from slow cooling of the heavy cross-sections of metal through the sensitizing range during casting. Tests were performed which indicated that, for the wall thickness involved, a very drastic quench was necessary to prevent sensitization.

Remedy: The valve castings were replaced with extra low carbon-molybdenum stainless steel castings which performed satisfactorily in this service.[13]

Sigma Phase Embrittlement. There are few reported failures attributed to sigma phase embrittlement. When sigma phase does develop in operation or fabrication,

careful handling and subsequent remedial steps can be taken to eliminate the brittle phase.

One reported failure resulting from sigma phase involved cast stainless steel headers in a catalytic reforming furnace heater. Failure occurred at the time the unit was shut down and the header plugs were removed with impact wrenches. The unit operated in a temperature range of 1,000° F to 1,500° F in which sigma phase develops. An analysis of the failed header samples indicated very low room-temperature impact absorption and a susceptibility to sigma phase development.[11]

Another case involving the premature failure of a large Type 316 welding neck flange was reported. The flange suffered a brittle failure adjacent to the weld during the hydrostatic test of the piping by the fabricator. Figure 10 shows the predominance of the brittle sigma phase. Tests showed the flange to be extremely brittle, evidenced by the low impact strength of 2 ft-lb to 3 ft-lb at room temperature. Metallographic examination revealed that the embrittlement was the result of sigma phase precipitation. Since this failure, it was found that some castings with analyses similar to Types 304, 347, and 316 become brittle after operation at temperatures within the sigma phase precipitation range.

Attempts were made to control the chemistry of the stainless steel castings with compositions equivalent to Types 347 and 316 to prevent sigma phase formation. It was found impractical because the composition ranges were too narrow. The use of these materials in cast form was discontinued for high-temperature service; however, Type 304 forgings should be suitable for such service.[13]

Condensed from a paper originally presented before the API Division of Refining Meeting, Detroit, May 9, 1960.

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More About Corrosion

Refinery Corrosion Inhibitors Studied. The industry has been using organic film-forming inhibitors in process streams for several years. By their use, many refiners have controlled corrosion caused by sulfides, chlorides, organic acids, oxygen, and other compounds in the presence of water, where alloy or other methods were not adequate or economical. Inhibitors have also reduced fouling of equipment caused by corrosion products or sludges. Their general acceptance is indicated by the level of usage in the industry. Information furnished by several companies shows refiners spend approximately $1 per thousand barrels of crude oil charge or $3 million per year for the organic inhibitors in process streams.

The most common applications are in crude oil tower overhead streams. On an over-all basis, inhibitors were effective, i.e., produced good or fair inhibitive results, in 87.5 percent of all applications reported. With few exceptions, reported inhibitive and detergent actions decreased rapidly at operating temperatures higher than 300° F. ("Corrosion Inhibitors in Refinery Process Streams," D. L. Burns, Gulf Oil Corp., Port Arthur, Texas, R. L. Hildebrand, Sinclair Refining Co., Harvey, Ill., P. D. Thomas, Asiatic Petroleum Corp., New York, N. Y.)

High Temp-Iron-Hydrogen Sulfide: The mechanism of the iron-hydrogen sulfide reaction was studied in the 500° C to 760° C temperature range for a total gas pressure of one atmosphere. The rate of attack was essentially constant (linear law), and the corrosion scale was composed of two layers: a thin dense layer adjacent to the metal and a porous layer with a coarse crystalline structure. These two features which differentiate this reaction from the iron-sulfur vapor reaction are interpreted on the basis of two main effects: (1) partial blocking of reaction sites by hydrogen produced during attack, and occurrence of a reaction at a constant number of reaction sites; and (2) continuous recrystallization of the dense scale into a porous scale offering no barrier to transport of reactants. This mechanism is self-regulating. ("Mechanism of Iron-Hydrogen sulfide Reaction at Elevated Temperatures," P. Delahay, La. State Univ., Baton Rouge, La.; H. Arm, Univ. Bern, Switz.; C. Hudgins, Continental Oil Co., Ponca City, Okla.; F. Hugli, Tech. High School, Winterthur, Switz.; L. Hulett, DeRidder, La.; M. Qureshi, Muslim Univ., Aligarh, India.)

Corrosion Probe Survey: The Subcommittee on Corrosion of the API Division of Refining conducted a survey designed to uncover the potential use of corrosion probes and the causes of and degree of limitations of the technique so that the technique could be used to best advantage in petroleum refineries. The paper summarizes the results of the survey and proposes that new refinery units be provided with standardized probe parts in certain specific locations on a routine basis. ("Use of Corrosion Probes in Petroleum Refining," Andrew Dravnieks, Standard Oil Co. (Ind.), Whiting, Ind.)

A SPECIAL REPORT

PROCESS SESSION

Get Cheaper Coking Now With This New Design

Fluid Coking has been re-engineered to improve its design and economics. You will want to include these new cost data in your present evaluations

A. L. Saxton, H. N. Weinberg, and R. O. Wright
Esso Research and Engineering Co., Madison, N. J.

FLUID COKING was developed by the Esso Research and Engineering Company in the early 1950s to meet the growing need for an efficient process for converting residual stocks into more valuable products.[1,2] Now the process has been re-engineered to improve the design and reduce costs.

To date, there is over 100,000 barrel per stream day of Fluid Coking capacity in the United States and Canada. These existing units were designed mainly on the basis of pilot plant data[3] and nearly simultaneously. Now the original design criteria have been reviewed and modified to incorporate firmly established improvements and know-how into an existing process.

Total onsite plant investment has been drastically reduced—from approximately $350 per barrel of fresh feed to $230 per barrel in the capacity range of 10,000 barrels per stream day. The operating costs associated with an improved coker are approximately 75 percent and utility investments approximately 35 percent of previous typical Fluid Coker designs. This has been accomplished with no sacrifice in product yields or qualities. The inherent flexibility of the process has been retained, and unit operability has been improved.

Fundamentals of the Process. Basically, Fluid Coking is a continuous heat-balanced, fluidized-solids process as shown in Figure 1. Fresh feed, usually a heavy residuum, is dispersed into the fluidized coke bed of a reactor operating typically between 900° F and 1,000° F. The thermal conversion products, including gas and a full-boiling-range distillate, leave the reactor as overhead vapors. A portion of the charge stock is converted to coke, which is deposited on the fluidized coke particles already in the reaction zone. Heat balance is accomplished by circulating coke between the reactor and the burner, where a portion of the gross coke make is burned with blower air to supply preheat and heat of reaction. The net coke is withdrawn as a product through an elutriator which returns fines to the burner.

The gas and distillate products leave the reactor through cyclones and enter a tower atop the reactor. In this tower, called a scrubber because any fine coke carryover is scrubbed from the reactor vapor, the vapors are partially condensed. The high-boiling distillate is recycled to the reactor and coked to extinction. The remaining vapor can then be fractionated into gas, naphtha, and light and heavy gas oil products.

That is still the basic process. However, the process and mechanical design of the equipment for conducting the process has been streamlined.

In the New Design. Figure 2 is a simplified flow plan of the improved coker. One interesting feature of the new design is the method for handling recycle. The relatively cool fresh feed is mixed ahead of the feed pumps with a stream withdrawn from the bottom of the scrubber tower. A portion of this mixture then goes directly to the reactor, and the balance is used for heat removal and wash in the desuper-heating section and quench pot of the scrubber tower. Thus the scrubber bottoms stream consists of recycle plus fresh feed.

By combining fresh feed and recycle in this manner, it has been possible to achieve significant savings in equipment investment. For example, it was possible to eliminate recycle exchangers, pumparound exchangers, pumps, piping, and the feed-injection system associated with a separate recycle system. The quench pot of the scrubber tower has been designed with adequate surge capacity so that a separate feed surge drum is not required, even when the coker follows a pipe still without intermediate tankage. Instrumentation in this system is considerably simplified in comparison with that previously required.

In the scrubber tower only the material boiling above the initial vapor temperature of the recycle (often referred to as "recycle cut point") is condensed for withdrawal. All net product is taken overhead from the scrubber tower to a separate fractionator. In the sepa-

rate fractionator a heavy gas oil stream is cut as fractionator bottoms. One portion of this stream is returned to the top of the scrubber tower as pumpback reflux to provide additional heat removal and fractionation in that zone. Another portion is used as pumparound for heat removal in the fractioning tower. The balance of the stream is withdrawn as net product.

By selection of gas oil boiling range and operating pressure, it is possible to adjust withdrawal temperature so the heavy gas oil stream can be used to produce all the high-pressure steam requirements of the unit. Part of the unit's low-pressure steam requirements can also be produced by the heavy gas oil stream.

A light gas oil cut is withdrawn as a sidestream in the fractionator. Like the heavy gas oil stream, a portion is used as pumparound for fractionator heat removal. Another portion is returned below the drawoff point as pumpback reflux, and the balance is withdrawn as net product. This stream is also used for steam generation. The total steam-producing capacity of the two gas oil streams is in excess of the unit requirements, so that the coker is a net steam producer.

Naphtha and gas products are taken overhead. Naphtha is also used as pumpback reflux.

Some Auxiliary Equipment Is Omitted. It is pertinent to consider some of the equipment deletions which have been made. The improved coker has a much simpler feed-injection system. The new system is, in part, based on extensive studies of coke circulation patterns conducted on a commercial unit with radioactive tracers. The studies showed that fluidization is excellent throughout the reactor, particularly in the area where feed is injected.

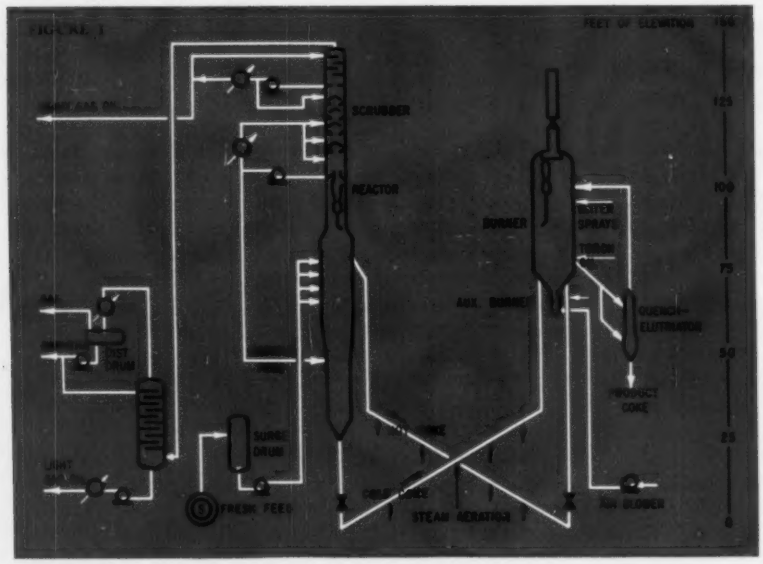
Successful operation of Fluid Coking units is very dependent on continuous coke circulation between the reactor and burner. Thus, in the early commercial units, a conservatively large number of aeration taps were installed on the transfer lines between the reactor and the burner. New data indicate that many less taps are needed. The savings in piping and associated facilities are significant. It was also found that the transfer lines could be made smaller and still have adequate circulating capacity.

Certain items of equipment originally specified on the basis of catalytic cracking plant experience have been found unnecessary on the cokers. Burner dilute phase sprays and torch oil connections are illustrative of this point.

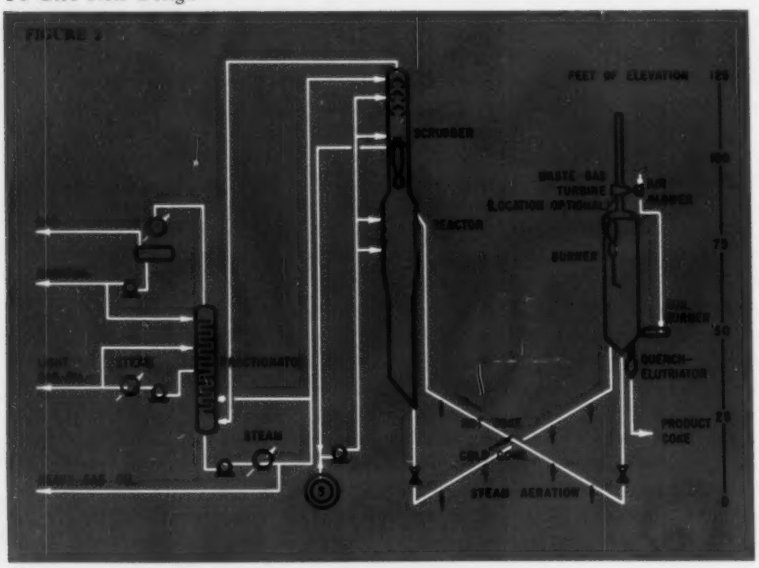
Changes to the Burner. Other improvements were made on the burner itself. The auxiliary burner required for startup purposes was relocated. This burner has normally hung from the bottom of a main burner or regenerator. In the new coker design, it is placed at right angles to the burner wall. The air distributor in the burner was also made considerably simpler. Part of the simplification is related to the relocation of the auxiliary burner.

The product coke elutriator, which in the past has been a separate vessel, has now been integrated with the

Old Design, Re-engineered . .



To Give New Design



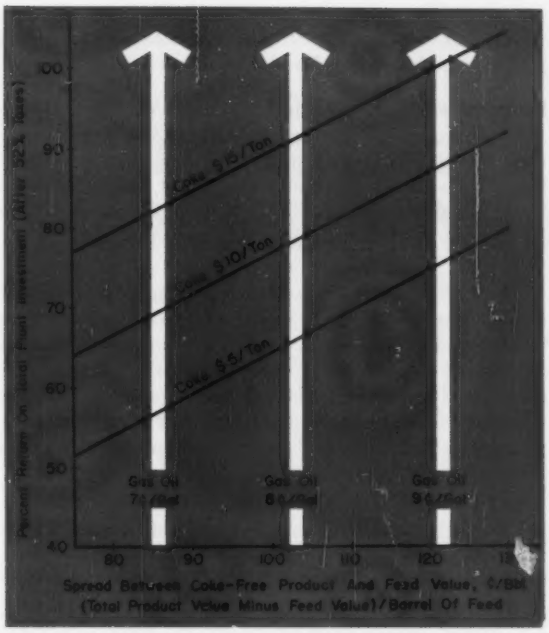


FIGURE 3—Arrows suggest approximate product-feed spread for various gas oil values assuming a typical product distribution and price structure.

burner. Coke fines will still be elutriated by countercurrent stripping. Besides saving money, it is anticipated that elutriation will be improved over that obtained with the previous separate-vessel elutriator. Turnaround time will also be shortened since coke removal from the burner has been simplified.

New Layout. The layout selected for the improved coker will require less plot area than most of the previous designs, with concomitant savings in piping and structural steel. Further analysis of the present design has shown that, in addition to the features already discussed, nearly 50 other design details were changed. Each of these small changes saved between one-fourth and one-half of 1 percent of the unit investment. This is an important factor. It means that the accumulation of many small savings, achieved by careful attention to design detail, had a major effect on the total cost.

Waste Gas Turbine Integrated into Process. An optional feature of the improved coker is the integration of a waste gas turbine into the process to drive the air blower. To accomplish this integration, the system pressure level would be raised to maximize power recovery from the waste gas turbine. This change in unit pressure would also lower overall burner height by approximately 30 percent and slightly decrease the size of other major equipment. Except on very large units, the waste gas turbine would be integral with the air blower. Because of the relatively small size of the integral machine, savings could be made by physically locating it on top of the burner. This reduces pressure drop and minimizes the length of flue gas lines upstream and downstream of the turbine. The relocation of the auxiliary burner discussed in the foregoing has an additional advantage if the air blower is located on top of the burner inasmuch as savings in air piping result.

In certain situations, it might be desirable to use a waste gas turbine to drive the coker gas compressor instead of the air blower. In either case, conditions for long-time satisfactory operation of a waste gas turbine have been established.

Highly Versatile Unit. The over-all result of the redesign is a modern unit which embodies many of the latest features available in refinery technology. And, it is a very flexible unit. For example, the change in process flow will facilitate operation at widely varying recycle cut points. In the situation where coker gas oil is used as feed to a catalytic cracker and the catalytic cracker has excess carbon-burning capacity, it would be easy to maximize coker gas oil. Alternatively, where the catalytic plant may be limited by feed rate or carbon-burning capacity, a coker gas oil of higher quality can easily be produced by lowering the cut point.

Table 1 shows the change in product distribution from one coker feedstock when operating at three typical recycle cut points. The yields are all based on the same reactor operating conditions. Reactor conditions can be adjusted to further alter yield and quality patterns. Table 1 also shows the change in catalytic cracking plant carbon yields for a given catalytic conversion level when feeding the different cut point coker gas oils. In this case, it has been assumed that 70 percent of the catalytic unit feed is virgin gas oil and the balance is coker gas oil.

Because of its flexibility, the Fluid Coker fits in with the growing industry trend to increase efficiency by replacing small multiple units with a single large unit. The simplicity of the Fluid Coker gives it an advantage

TABLE 1—Effect of Recycle Cut Point* on Product Distribution
(Feed: Vacuum Residuum, 3.2 Degrees API; 24 Percent by Weight of Conradson Carbon)

Case:	I	II	III
Recycle IVT, deg F*	1,015	950	850
Recycle, percent by volume	25	30	50
Product distribution, percent by weight on fresh feed:			
C_3—	10.0	10.8	11.9
C_4	1.8	1.9	2.1
C_5 to 430 F	14.7	15.9	17.6
430 F to FVT*	44.7	41.1	34.7
Net coke	23.0	24.2	26.9
Coke burned	5.8	6.1	6.8
Total	100.0	100.0	100.0
Gas oil quality (430 F to FVT*):			
Conradson carbon residue, percent by weight	2.6	1.5	0.5
Relative carbon yield for 30-70 coker-virgin gas oil catalytic cracking feed mixture compared to all virgin feed, at constant conversion	1.63	1.26	1.08

* Recycle cut point corresponds to recycle initial vapor temperature (IVT), which is also equivalent to gas oil final vapor temperature (FVT).

over competitive processes, particularly for very high capacities.

The improved coker also lends itself to a variety of refinery processing schemes. The combination of high temperature and high vapor rates available from the Fluid Coker enables it, in certain situations, to perform the additional function of a vacuum pipe still. This is accomplished by feeding atmospheric bottoms directly to the scrubber for further distillation. The bottoms from this operation is fed directly to the coker reactor together with recycle feed.

One of the many situations in which a coker can be justified is the existence of excess bunker stocks. For example, it is feasible to combine Fluid Coking and either thermal or catalytic cracking to maximize gasoline production and minimize both fuel oil and middle distillates. Alternatively, heavy gas oil can be minimized and production of coker middle distillate can be increased without requiring subsequent cracking processes. Fluid Coking has already been applied in a refinery where variations in asphalt demand created a seasonal surplus of vacuum capacity which was out of balance with the rest of the refinery. Profitable utilization of this refining capacity to run incremental crude oil was made possible by the Fluid Coker.

TABLE 2—Economics of Improved Fluid Coker
(Basis: Fresh Feed, 10,000 Barrels per Stream Day; Vacuum Residuum, 3.2 Degrees API; 24 Percent by Weight of Conradson Carbon)

Investment, thousands of dollars:	
Process	2,300
Offsite and utility	750
Total for plant	3,050
Utility requirements:	
125-psig steam, lb. per hour*	(6,000)
Power, kw	150
Cooling water, gpm	3,600
Boiler feedwater, gpm	110
Refinery air, std cu ft per minute	300
Manpower:	
Operators per shift	3
Operating costs, cents per barrel†	20‡

* Net steam producer.
† Based on average present-day Gulf Coast costs, including depreciation. Fuel valued at 30 cents per million Btu and wage rate of $2.90 per hour. Excludes royalty.
‡ Assumes use of a waste gas turbine to drive air blower. Operating costs would be increased to 25 cents per barrel if an alternate driver were selected.

Economics. Naturally, the economics of Fluid Coking will vary from one refinery to another. Size, for example, may be a significant variable. It has previously been stated[2] that a typical 4,000-bpsd Fluid Coker showed a return of approximately 25 percent, while one of 42,000-bpsd capacity showed a return of approximately 57 percent.

Another factor is the value of the coke product. Although most Fluid Coke has been burned as fuel, there is considerable interest in Fluid Coke among metallurgical industries and other coke consumers.[4] It is anticipated that current studies by Esso Research and Engineering Company, Fluid Coke producers, and coke-consuming industries will lead to a rapid growth in the Fluid Coke market.

A typical picture of investment, operating cost, and profitability is presented in Table 1 and Figure 3. Figure 3 particularly illustrates the fact that coke-free product values usually have a greater effect than coke value in determining the return on investment for Fluid Coking. In the special situation where the Fluid Coker can also replace a vacuum pipe still, as discussed in the foregoing, its profitability should be substantially greater than the typical returns shown in Figure 3.

Original presentation was before the API Division of Refining Meeting, Detroit, May 12, 1960.

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More About Processes

New Processes Help Refiner. Current refining trends are toward improved motor and road gasoline octane ratings, more complete utilization of gaseous olefins as alkylation feed, and increased quantities and quality of jet fuels. Processes are available which enable refiners to profit by any or all of these trends. Gasolines can be upgraded by the inclusion of alkylate, by isomerization of low quality C_5-C_6 fractions, or by the removal of low-octane normal paraffins.

In some areas isobutane availability is becoming a problem because of a general increase in alkylation capacity. Isobutane can be produced by the Butamer process which in turn can be operated in conjunction with the alkylation of propylene and butylenes.

The Penex process, in commercial operation for nearly three years, has demonstrated it can successfully upgrade C_5-C_6 fractions.

With many reformers presently being operated at high severity conditions, refiners must look to other means to improve the motor octane rating of their finished gasoline, for high reforming severity in most cases raises concentration of the aromatics in the reformate and increases the sensitivity of the final product. Extraction of low-octane paraffin fractions can be obtained by the Molex process. It not only fulfills refiners' needs in improving gasoline road performance, but also provides a jet fuel of lower luminosity than any marketed today. The low luminosity fuel is valuable in terms of better jet engine performance, longer engine life, and reduced maintenance costs ("Impact of Recently Developed Processes on Refining Technology," R. C. Kersten and G. F. Asselin, Universal Oil Products Co., Des Plaines, Ill.)

A SPECIAL REPORT

PROCESS SESSION

How Much You Can Save With The Isocracking Process

Here are material balances for typical refineries converting middle distillate to gasoline. These cases demonstrate the advantage of the Isocracking process for control of product distribution and quality

J. W. Scott, J. A. Robbers, N. J. Paterson, H. M. Lavender
California Research Corporation, Richmond, Calif.

ISOCRACKING is a new hydrocracking process which converts refractory stocks in excellent yields to higher value products. The economics of the process are favorable since moderate operating conditions and conventional equipment are used. Commercial feasibility of the process has been demonstrated by nearly a year's operation of an Isocracker in Standard Oil Company of California's Richmond refinery.[1,2] During this period, further pilot plant information has been obtained to support evaluations of Isocracking in a wide variety of refining applications.

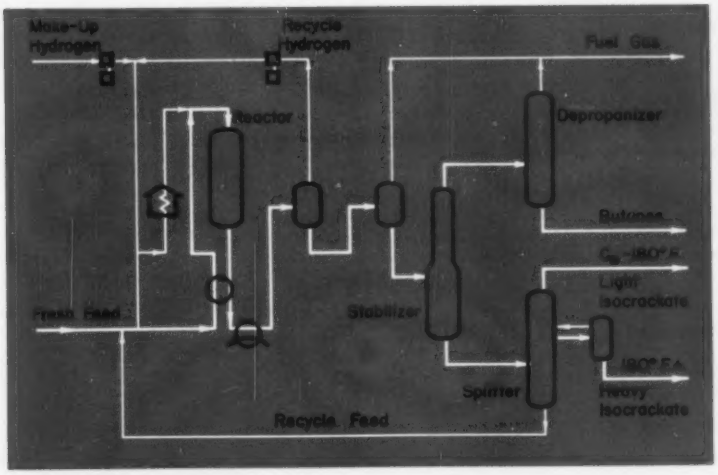
A series of refinery balances is given here to show

HOW ISOCRACKING WORKS

Process flow for Isocracking is similar to previous hydrocracking processes. Operating conditions are, however, less severe. Temperatures are in the range of 400°F to 700°F; pressures are typically 500 psig to 1,500 psig. Hydrogen consumption also is moderate—1,100 to 1,600 std cubic feet per barrel of feed converted.

Typical feeds include cracked and straight-run middle distillates. However, a heavy catalytically cracked cycle oil boiling in the range of 565°F to 840°F has been satisfactorily Isocracked on a pilot scale. Most stocks need hydrofining to prepare them for Isocracking. The process may be operated once-through for production of gasoline and a bottoms product. The latter can be fractionated to give a jet fuel component or marketed as a high-quality middle-distillate stock. Alternatively, the process may be operated at extinction recycle (of material boiling higher than the desired gasoline cut point), with a net conversion of approximately 60 percent per pass.

The whole liquid product from recycle operation can be used for gasoline blending. However, it is preferable to split this product into a light Isocrackate (C_5 to approximately 180°F) and a heavy Isocrackate, as shown. Light Isocrackates contain higher than equilibrium concentrations of isoparaffins and have leaded octane ratings of approximately 100 by both the Research and Motor Methods. They are valuable premium-gasoline blend stocks. Heavy Isocrackates contain relatively high concentrations of naphthenes and aromatics. In some cases, they are used directly as components of regular gasoline. They are, however, excellent reformer feedstocks. Reformates prepared therefrom run one to three octane numbers higher than would be expected for a normal reformer feed of the same component analysis and boiling range.



For more details on how the process converts specific classes of compounds see: "How Isocracking Works," PETROLEUM REFINER, Vol. 39, No. 4, p. 155 (April, 1960).

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some of the relationships between Isocracking and catalytic cracking. These balances are directed toward middle-distillate conversion. A case is presented for an East Coast refinery faced with increased gasoline demand but a constant No. 2 oil market. Excess crude oil running capacity is assumed available. A second case represents a West Coast refinery which has installed coking facilities to reduce bunker fuel oil production. In this case, Isocracking is compared with additional catalytic cracking capacity for conversion of refractory middle distillates to additional gasoline at constant crude oil input. These cases demonstrate the advantages of the Isocracking process for control of product distribution and improved quality. Conclusions drawn therefrom are applicable to similar refining situations in the Mid-Continent and Gulf Coast areas. Analyses show that Isocracking is more attractive economically than catalytic cracking in these situations.

TABLE 1—Middle-Distillate Conversion—Isocracking Vs. Catalytic Cracking
East Coast Refinery—Middle East Crude Oil (34.5 Degree API)

	Base	Fluid Catalytic Cracking		Isocracking	
Refinery Input, BPCD					
Crude oil	100,000	113,000		113,000	
Isobutane	568	1,638		0	
nButane	1,363	1,050		715	
Products, BPCD					
No. 2 oil	30,153	30,153		30,153	
Kerosine plus commercial jet fuel	6,000	6,000		6,000	
Motor gasoline	43,784	53,457		55,251	
Research octane number, with addition of 3 ml TEL per gal.	95.9	95.9		95.9	
Motor octane number, with addition of 3 ml TEL per gal.	87.4	88.0		88.9	
Fuel oil (175 SFS at 122° F)	18,866	21,296		21,346	
Gas (FOE*)	4,091	6,167		4,527	
		Existing	Added	Existing	Added
Processing Rates, BPCD					
Crude oil unit (feed)	100,000	113,000	.....	113,000	.....
Reformer (feed)	10,000	11,300	.....	11,300	.....
Research octane number of reformate, with addition of 3 ml TEL per gal.	96	95	.....	95	.....
Fluid catalytic cracking unit:					
Ratio of fresh feed to total feed.	35,000/ 52,500	31,500/ 47,250	11,550/ 17,325†	39,550/ 52,500	.....
Conversion, percent	65	70	70	61	.....
Coke, lb. per calendar hour	28,700	28,700	10,500	28,700	.....
C_4 alkylation (product)	4,820	4,820	2,722†‡	4,820	.....
C_3 polymerization (product)	1,490	1,490	.....	1,510	.....
Hydrodesulfurization (feed)	5,850	5,414	.....	1,914	.....
Hydrofining and Isocracking (feed)	.....	.....	.....	.....	7,974†
Hydrogen plant (product), million SCFCD	.....	.....	.....	.....	13.5†

* Fuel oil equivalent.
† New plants.
‡ Alkylation of incremental propylene and butylene.

TABLE 2—No. 2 Oil Composition and Yield of 10-Lb. Rvp Gasoline
East Coast Refinery—Middle East Crude Oil

	Base Case	FCC Case	Isocracker Case
Crude oil input BPCD	100,000	113,000	113,000
No. 2 oil, BPCD:			
Straight-run gas oil	24,303	24,739	28,239
Hydrodesulfurized catalytic cycle oil	5,850	5,414	1,914
Total	30,153	30,153	30,153
Gasoline from fluid catalytic cracking (FCC) and Isocracking, 10-psi Rvp, as percent by volume of FCC feed*	63.5	63.7	75.1

*Basis: Input includes feed to catalytic cracker and outside butanes.
Yields of 10-psi Rvp gasoline are based on:
Polymerization of propylene (75 percent recovered).
Alkylation of butenes (95 percent recovered).
Undercutting gasoline for viscosity balance to produce bunker fuel of 175 SFS at 122° F.
Pressuring to 10-psi Rvp with normal butane.

COMPARISON OF ISOCRACKING WITH ADDITIONAL CATALYTIC CRACKING

One of the characteristics of the catalytic cracking process is that the light-cycle-stock product is more resistant to further cracking than the original virgin feedstocks. This follows because the more easily converted portion of the virgin feed is the first to be cracked, and some aromatic formation is bound to occur in the absence of favorable hydrogenation conditions. In fact, it is axiomatic in catalytic cracking that the light cycle stocks become progressively more refractory with increasing conversion. In contrast, the attractiveness of Isocracking is frequently enhanced by operation on these refractory, high-aromatic-content materials.

To make a comparison between Isocracking and catalytic cracking for the East Coast refinery situation, it is assumed that the Isocracker is fed light catalytic cycle oil. The catalytic cracker feeds only the straight-run gas oil fractions, which it is better able to handle. Both processes can achieve a substantial increase in motor gasoline yield at constant No. 2 oil production.

Competition for the No. 2 oil market from other energy sources is a recognized trend in the industry. This has required improved quality to maintain a competitive position. It is assumed, therefore, that the East Coast refiner hydrodesulfurizes the catalytically cracked portion of his No. 2 oil for quality considerations. Because the addition of Isocracking may remove some of the cracked distillates from the No. 2 oil, a refiner may thus have hydrofining capacity available for integration into the Isocracking project.

The case for the West Coast refiner presents a different problem. As a result of the heavier crude oil processed, the yield of bunker fuel oil usually is higher than is obtained in the East. Heating oil demand is lower and is generally supplied from straight-run components. To reduce bunker fuel oil, many refiners have, or contemplate installation of, coking facilities. This creates the problem of disposal of additional quantities of cracked middle distillates. Isocracking to convert light coker and

TABLE 3—Gasoline Quality

	EAST COAST REFINERY			WEST COAST REFINERY		
	Base Case	FCC Case	Isocracker Case	Base Case	FCC Case	Isocracker Case
Crude oil input, BPCD	100,000	113,000	113,000	100,000	100,000	100,000
Gasoline production, BPCD	43,784	53,457	55,251	56,543	60,058	64,060
Research octane number, with addition of 3 ml TEL gal	95.9	95.9	95.9	94.7	95.0	94.9
Motor octane number, with addition of 3 ml TEL per gal	87.4	88.0	88.9	84.2	85.0	85.9
ASTM distillation, 50-percent point, degree F	198	198	195	218	216	205
ASTM distillation, 90-percent point, degree F	342	345	335	350	348	335
Reid vapor pressure, psi	10	10	10	10	10	10

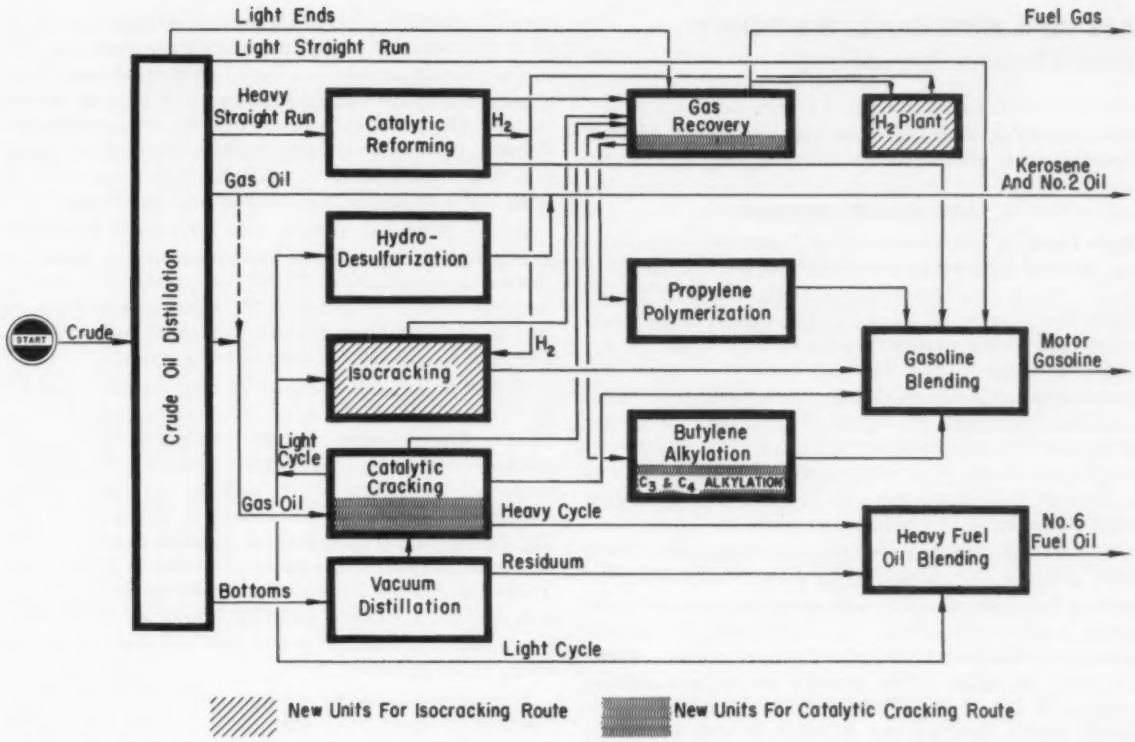

FIGURE 1—By adding Isocracking, East Coast refinery has process flexibility to meet a variety of product demands.

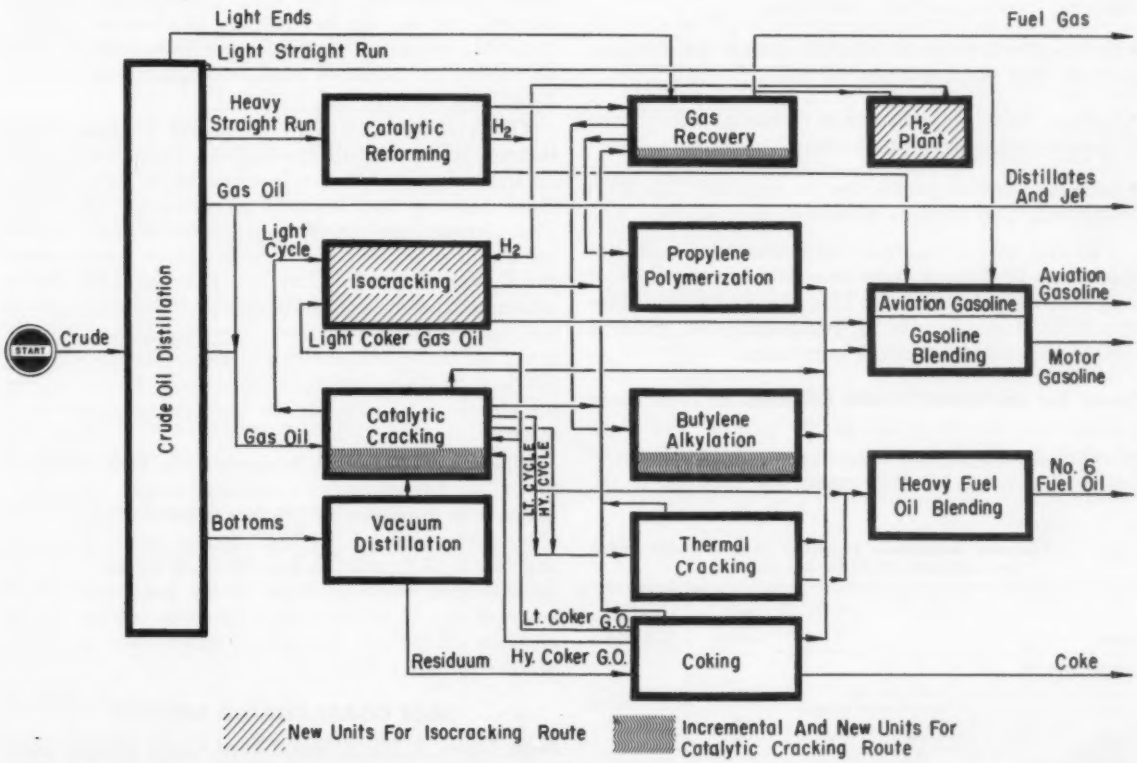

FIGURE 2—A typical West Coast refinery is also proposed to show how Isocracking would fit into a plant having a coker.

catalytic stocks is shown to be more attractive for this situation than additional catalytic cracking.

EAST COAST REFINERY

Base Case. A 100,000-bpcd East Coast refinery processing Middle East crude oil (34.5° API) is taken as a basis. The general processing scheme is shown in the block flow diagram in Figure 1. The details of the processing rates and product volumes and qualities are shown in Table 1. Six thousand bpcd of kerosine and commercial jet fuel and a maximum yield of straight-run No. 2 oil with a —15 F ASTM pour point are produced. The atmospheric residuum is vacuum-stripped to give maximum yield of catalytic cracking feedstocks as limited by heavy-metals content. The vacuum residuum yield is 11.4 percent to crude oil.

The existing catalytic cracking unit processes 35,000 bpcd of heavy gas oil feed at 65 percent conversion, 50 percent heavy recycle. The unit operates to gas and coke limits. Light catalytic cycle oil (5,850 bpcd, 2.7 percent by weight of sulfur) is hydrodesulfurized to give a product with the same sulfur content as the straight-run portion of No. 2 oil. Total No. 2 oil production is 30,153 bpcd. Butenes are alkylated and propylene polymerized. Isobutane requirements for alkylation, and normal butane for gasoline pressurizing, are augmented by outside purchases.

In setting up cases for the East Coast refinery, the following alternatives were considered:

- Reduce No. 2 oil production at constant gasoline production. This reduces crude oil run.
- Reduce No. 2 oil production at constant crude oil run. This increases gasoline production.
- Increase gasoline production at constant No. 2 oil production. This requires increased crude oil run.

The first two alternatives have relatively short-term objectives. The last is most reasonable in the light of projected market demands. This case is therefore presented for a comparison of Isocracking and catalytic cracking for middle-distillate conversion.

Cases for Increased Crude Oil Run. In these cases, it is assumed the refiner has 13,000 bpcd of extra crude oil running capacity and desires to increase gasoline volume while holding No. 2 oil production constant. In the catalytic cracking case, 3,500 bpcd of straight-run No. 2 oil is cracked, along with the heavy straight-run gas oil, in the existing unit plus a new 11,550-bpcd unit. Conversion is increased to 70 percent at 50 percent recycle on both units, and both units are coke- and gas-limited. Polymer production is held constant and a new alkylation plant, 2,722 bpcd of whole alkylate, is installed to process the incremental propylene and butylenes.

In the Isocracker case, a new 7,974-bpcd Isocracker is required, along with a hydrofiner and a hydrogen plant with a capacity of 13,500,000 scfpcd. The existing catalytic cracker processes 39,550 bpcd of heavy gas oil feed at 61 percent conversion, 33 percent heavy recycle. The unit is operated at coke-burning limits.

Shown in Table 2 is the 10-lb Rvp gasoline yield for each of the East Coast refinery cases. This gasoline yield is obtained from catalytic cracking or the catalytic cracking-Isocracking combination only. The higher efficiency of the Isocracker to convert refractory middle distillates to gasoline is demonstrated. These yields take into consideration undercutting gasoline from the catalytic cracker to maintain viscosity balance in the refinery. Table 3 shows the improvement in Motor octane rating and sensitivity obtained with the Isocracker for the East Coast refinery along with data for the West Coast refinery to be discussed later.

Economic evaluations are summarized in Table 4. Isocracking provides a 3.3-year payout, after taxes, while catalytic cracking has a 5.8-year payout. No dollar credit is taken for the improvement in gasoline sensitivity.

The payout on the incremental $1 million investment for the Isocracking alternative is 0.4 year, after taxes. This rapid payout results from the twofold increased earnings rate for the Isocracking case. Isocracking permits the conversion of middle distillates with a lower investment per barrel of gasoline produced, as noted in Table 4.

The economic incentives for adding the new alkylation unit to the catalytic cracking case have been studied. As an alternative, butylene in excess of the existing alkylation capacity may be used for gasoline pressurizing. This permits reduction of the purchased normal butanes but results in a direct loss of isobutane to gasoline from the C_4 cut of the fluid catalytic cracking unit. Excess propene above the polymerization plant capacity goes to fuel gas. Despite a decreased investment, this alternative is not attractive because of the substantial loss of gasoline and the downgrading of other stocks. Hence, it does not change conclusions drawn from the cases presented in detail.

When the 7,974-bpcd Isocracker has been installed, the refiner has processing flexibility to meet large deviations from the projected product demands. Some of the alternatives available for variation of crude oil input and No. 2 oil production are shown in Table 5. At the 100,000-bpcd crude oil input of the base case, installation of the 11,550-bpcd new catalytic cracker would give only 4,800 bpcd of additional gasoline for the 5,850-bpcd reduction in No. 2 oil.

TABLE 4—Economic Evaluation Summary of East Coast Refinery—Middle-Distillate Conversion

Process:	Fluid Catalytic Cracking	Isocracking
Project investment:		
Millions of dollars	14.2	15.2
Dollars per barrel of gasoline per calendar day	1,470	1,330
Amount available for payout, before taxes and amortization, dollars per calendar day	9,800	22,300
Project payout, years (after tax basis*)	5.8	3.3
Incremental payout for Isocracking over catalytic cracking, years	.....	0.4

* Income tax, 52 percent; depreciation, 10 percent.

WEST COAST COKING REFINERY

Base Case. A 100,000-bpcd West Coast refinery processing California crude oil (27.5° API) is taken as a basis. The general processing scheme is shown in the

block flow diagram in Fig. 2. The details of the processing rates and products are shown in Table 6.

This refinery, in the past operated a viscosity breaker on the vacuum column bottoms and thermally cracked the light and heavy catalytic cycle oils in excess of requirements for 175 SFS (Saybolt Furol seconds) at 122° F bunker fuel oil. To reduce fuel oil, the refiner is assumed to have replaced the viscosity breaker with a coker. The net result is a surplus of light cutter stocks which cannot be destroyed in thermal or catalytic units because of capacity limitations.

The catalytic cracker feeds 51,135 bpcd of a mixture of light and heavy straight-run and coker gas oils. It operates at 50 percent conversion. The unit is coke-limited at 35,000-pounds-per-calendar-hour coke burning. The light and heavy catalytic cycle stocks are

TABLE 5—Middle-Distillate Conversion—Operating Alternative with a 7,970-Bbl-per-Calendar-Day Isocracker Installed
East Coast Refinery—Middle East Crude Oil

Crude Oil Input (BPCD)	CHANGES FROM BASE CASE					
	MOTOR GASOLINE			BARRELS PER CALENDAR DAY		
	Barrels Per Calendar Day	Research Octane Number, With 3 Ml TEL Per Gal.	Motor Octane Number, With 3 Ml TEL Per Gal.	No. 2 Oil	No. 6 Oil	Butanes
113,000	+11,467	0.0	+1.5	0	+2,480	+1,216
100,000	+ 7,170	+0.1	+1.1	— 5,850	— 670	+1,120
80,000	0	+1.2	+1.2	—14,090	—6,150	+ 780

TABLE 6—Conversion of Catalytic Cracker Light Cycle Oil and Light Coker Distillate—Isocracking Vs. Catalytic Cracking
West Coast Refinery—California Crude Oil (27.5 Degree API)

	Base	Fluid Catalytic Cracking		Isocracking	
Refinery Input, BPCD					
Crude oil (including 3 percent natural)	100,000	100,000		100,000	
Isobutane	1,829	1,776		535	
Products, BPCD					
Excess light cycle oil	6,300	.....		.....	
Fuel oil (175 SFS at 122° F.)	9,763	9,153		9,551	
Aviation gasoline	3,600	3,600		3,600	
Motor gasoline	56,543	60,058		64,060	
Research octane number, with addition of 3 ml TEL per gal.	94.7	95.0		94.9	
Motor octane number, with addition of 3 ml TEL per gal.	84.2	85.0		85.9	
Distillates and commercial jet fuel	10,800	10,800		10,800	
Coke, *tons* per calendar day	778	778		778	
Gas (FOE*)	7,100	11,700		6,162	
Miscellaneous (asphalt, chemicals, etc.)	2,300	2,300		2,300	
nButane	815	616		617	
		Existing	Added	Existing	Added
Processing Rates, BPCD					
Crude oil unit (feed)	100,000	100,000	.....	100,000	.....
Two-stage reformer (feed)	17,000	17,000	.....	21,700†	.....
Research octane number of reformate, with addition of 3 ml TEL per gal.	101	101	.....	101	.....
Fluid catalytic cracking unit: Ratio of fresh feed to total feed.	51,135/ 62,750	32,828/ 62,250	18,307/ 35,000‡	47,763/ 62,250	.....
Conversion, percent	50	65	65	51	.....
Coke, lb. per calendar hour	35,000	35,000	33,500	35,000	.....
C_4 alkylation (product)	6,137	6,137	1,083‡	5,633	.....
C_3 polymerization (product)	1,518	1,654	.....	1,437	.....
Thermal cracker (feed)	19,000	18,000	.....	18,000	.....
Coker (feed)	18,000	18,000	.....	18,000	.....
Hydrofining and Isocracking (feed)	.....	.....	.....	.....	8,878‡
Hydrogen plant (product), million SCFPD	.....	.....	.....	.....	8.1‡

* Fuel oil equivalent.
† Increased capacity possible because Isocrackate is included in feed.
‡ New plants.
‡ Incremental new equipment.
‡ Consists of 3,372 BPCD of light coker distillate and 5,506 BPCD of FCC light cycle oil.

TABLE 7—West Coast Coking Refinery Yield of 10-Lb. Rvp Gasoline

Basis: **Input of 100,000 BPCD of Crude Oil (27.5 Degree API) Constant No. 2 Oil and Jet Fuel Production**

	Base	Additional FCC	Base FCC Plus Isocracker
Gasoline from FCC plus Isocracker, 10-psi Rvp, percent by volume of FCC feed*	49.9	57.5	66.5
Excess cracked cutter over 175 SFS at 122° F fuel, bbl per calendar day	6,300	0	0

* **Basis:** Input includes feed to catalytic cracker and light coker gas oil to Isocracker.
Yields of 10-psi Rvp gasoline are based on:
Polymerization of propylene (75 percent recovery).
Alkylation of butylenes (95 percent recovery).
Pressuring to 10-psi Rvp with normal butane.

TABLE 8—Economic Evaluation Summary of West Coast Coking Refinery—Conversion of Light Catalytic Cycle Oil and Coker Distillate

PROCESS:	Fluid Catalytic Cracking	Isocracking
Project investment, dollars	17,000,000	15,700,000
Amount available for payout, before taxes and amortization, dollars per calendar day	8,100	22,000
Project payout, years (after tax basis*)	7.4	3.4

* Income tax, 52 percent; depreciation, 10 percent.

TABLE 9—Operating Flexibility by Varying Type of Isocracker Feed
East Coast Refinery—Middle East Crude Oil
Crude oil run: 113,000 barrels per calendar day
Catalytic cracker feed: 39,550 barrels per calendar day

Isocracker Feed:	Light Catalytic Cycle Oil (Isocracker Case, Table 1)	Front End of Catalytic Cracker Feed
Overall conversion, percent*	79.9	67.2
Yields, based on heavy gas oil:		
C_5+ gasoline	64.5	50.4
Heating oil (600° F. end point)	4.8	24.0
Heavy cycle oil (600 F+)	15.3	8.8
Total 10-lb. Rvp gasoline, percent†	75.1	62.5

* Overall conversion is 100 percent minus percent of net cycle oils produced.
† 10-lb. Rvp gasoline yield based on:
Polymerization of propene (75 percent recovery).
Alkylation of butenes (95 percent recovery).
Undercutting gasoline for viscosity balance to produce bunker fuel of 175 SFS 122° F.
Pressuring with normal butane.
Yields covering catalytic cracking-Isocracking combination only.

TABLE 10—Investment Summary of Middle-Distillate Conversion

Refinery location:	East Coast		West Coast Coking Refinery	
Middle-distillate conversion process:	Fluid Catalytic Cracking	Isocracking	Fluid Catalytic Cracking	Isocracking
Process plant investments, millions of dollars:				
Fluid catalytic cracker	6.8	....	11.0	....
Alkylation unit	3.4	....	0.9*	....
Hydrofiner	....	2.3	....	2.8
Isocracker	....	6.2	....	7.0
Hydrogen plant	....	3.1	....	2.3
Total process plants	10.2	11.6	11.9	12.1
Offplot	4.0	3.6	5.1	3.6
Total investment	14.2	15.2	17.0	15.7

* Additions to existing plant.

thermally cracked in existing thermal units at 2.5:1 combined feed ratio and 12 percent crack per pass. Butylenes are alkylated, and propylene is polymerized. Additional isobutane is purchased for alkylation. Excess light cycle stocks, 6,300 bpcd, when added to the 175 SFS at 122° F bunker fuel production reduce the No. 6 oil viscosity to 80 SFS at 122° F. Thirty-six hundred bpcd of aviation gasoline is produced; jet and No. 2 oil are straight-run products.

Addition of Catalytic Cracking Capacity to Base. To bring the refinery back into viscosity balance, a new 18,307-bpcd catalytic cracking unit is added to the base case. Conversion on both cracking units is raised to 65 percent by distributing the feedstocks. The lighter portions of the feed are processed in the existing unit. This utilizes its coke and gas-handling capacities. The heavier portion, which gives high coke yields, is processed in the new unit. Light and heavy cycle stocks, in excess of the amount required for blending No. 6 oil to 175 SFS at 122° F, are thermally cracked in existing units. The additional alkylate is diverted to motor gasoline. Additional isobutane for alkylation is purchased.

Addition of Isocracking to Base. In this case, the Isocracker is fed the light coker and catalytic cycle oils in excess of the amounts required for viscosity balance, while maintaining the existing thermal units at capacity as in the previous cases. The existing fluid catalytic cracking unit processes the base feed without inclusion of light coker gas oil. This permits a small increase in conversion and recycle to utilize gas-recovery and coke-burning capacities. A new 8,000,000-scfpcd hydrogen plant is required to supplement the supply from the existing catalytic reformer.

A yield of 10-psi Rvp gasoline for each case is shown in Table 7. Again, the higher efficiency of the Isocracker for converting refractory middle distillate to gasoline is demonstrated. Gasoline yields are those obtained from the catalytic cracking or catalytic cracking-Isocracking combination only, inasmuch as coking and thermal cracking are approximately constant. Table 3, referred to earlier, shows the improvement in sensitivity of the gasoline pool with the Isocracker added. If the comparison had been made at reduced crude oil input and constant gasoline for the Isocracker case, an improvement of approximately 1.0 Research octane number on the pool would have been obtained by reforming the heavy Isocrackate.

The economic evaluations for addition of catalytic cracking or Isocracking to the base case are summarized in Table 8. The higher gasoline yield from Isocracking results in the 3.4-year payout for the Isocracking project compared to the 7.4 years for catalytic cracking. As in the previous case study, we have not assigned a value to improved sensitivity.

PROCESS FLEXIBILITY

In the evaluation of a process, the operating flexibility which can be obtained is an important consideration.

TABLE 11—Economic Evaluation of East Coast Refinery—Middle-Distillate Conversion
Changes from Base Case

Middle-distillate conversion process:		Fluid Catalytic Cracking		Isocracking	
Project investment, dollars:		14,200,000		15,200,000	
	Unit Value (Dollars Per Barrel)	Barrels Per Calendar Day	Thousands of Dollars Per Calendar Day	Barrels Per Calendar Day	Thousands of Dollars Per Calendar Day
Feed Cost					
Crude oil	3.00	13,000	+39.0	13,000	39.0
Tetraethyllead	($2.20 per liter)	.....	2.7	.....	3.2
Subtotal			41.7		42.2
Production Realization					
Motor gasoline	5.50	9,673	53.2	11,467	63.1
Fuel oil	2.40	2,430	5.8	2,480	6.0
Fuel gas (FOE*)	2.25	2,076	4.7	436	1.0
Isobutane	4.50	—1,070	—4.8	568	2.6
nButane	3.25	313	1.0	648	2.1
Subtotal			59.9		74.8
Operating Costs					
New Plants:					
Catalytic cracker	....	11,550	4.6	.....	....
Alkylation unit	....	2,722	3.3	.....	....
Hydrofiner	....	.....	.....	7,974	1.8
Isocracker	....	.....	.....	7,974	4.6
Hydrogen plant (million SCFCD)	....	.....	.....	(13.4)	3.3
Existing plants	....	.....	0.5	.....	0.4
Subtotal			8.4		10.3
Amount available for payout			9.8		22.3
Project payout, years:					
Before taxes		4-0		1-87	
After taxes—income tax, 52 percent; depreciation, 10 percent		5.8		3.3	

* Fuel-oil equivalent.

TABLE 12—Economic Evaluation of West Coast Coking Refinery—Conversion of Light Cycle Oil and Coker Distillate
Changes from Base Case

Middle-distillate conversion process:		Fluid Catalytic Cracking		Isocracking	
Project investment, dollars:		17,000,000		15,700,000	
	Unit Value (Dollars Per Barrel)	Barrels Per Calendar Day	Thousands of Dollars Per Calendar Day	Barrels Per Calendar Day	Thousands of Dollars Per Calendar Day
Product Realization					
Excess cutter*	1.50	—6,300	—9.5	—6,300	—9.5
Motor gasoline†:					
Premium (100 octane number)	6.00	1,406	8.4	3,007	18.0
Regular (91.5 octane number)	4.75	2,109	10.0	4,510	21.4
Tetraethyllead	($2.20 per liter)	.....	—0.3	.....	—2.1
Fuel oil	1.50	—610	—0.9	—212	—0.3
Fuel gas (FOE‡)	2.00	4,600	9.2	—938	—1.9
Isobutane	4.50	53	0.2	1,294	5.8
nButane	3.25	—199	—0.6	—198	—0.6
Subtotal			16.5		30.8
Operating Costs					
New units:					
Catalytic cracker	....	18,307	6.7	.....	....
Alkylation unitΣ	....	1,083	1.0	.....	....
Hydrofiner	....	.....	....	8,878	2.0
Isocracker	....	.....	....	8,878	5.1
Hydrogen plant (million SCFCD)	....	.....	....	(7.7)	2.1
Existing plants	....	.....	0.7	.....	—0.4
Subtotal			8.4		8.8
Amount available for payout			8.1		22.0
Project payout, years:					
Before taxes		5.7		1.95	
After taxes—income tax, 52 percent; depreciation, 10 percent		7.4		3.4	

* Excess cutter taken at No. 6 fuel oil value.
† Gasoline pool: premium, 40 percent; regular, 60 percent.
‡ Fuel oil equivalent.
Σ Incremental operating cost basis.

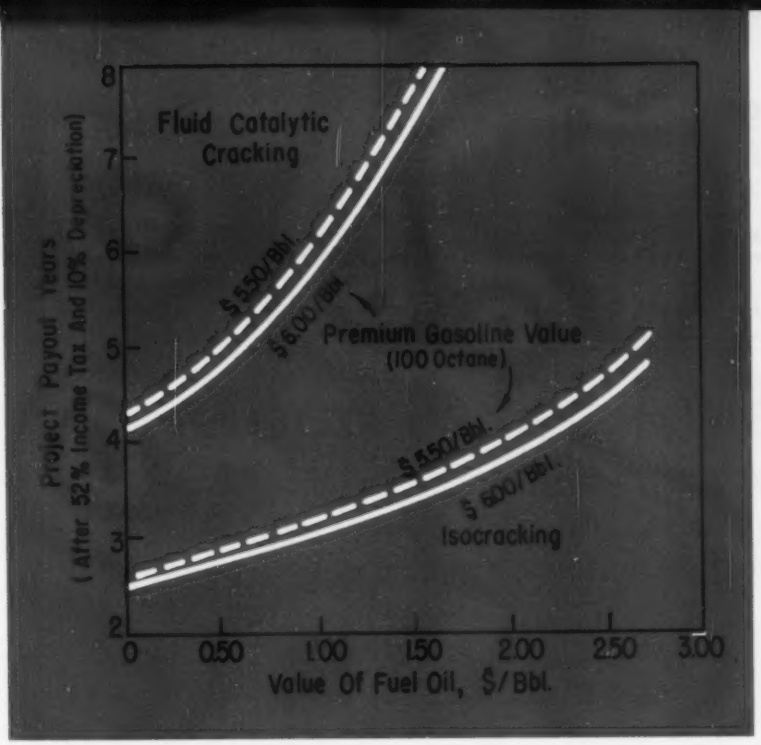

FIGURE 3—Here is the payout for Isocracking compared with catalytic cracking in a West Coast coking refinery.

The Isocracking-catalytic cracking combination offers a high degree of flexibility compared to alternative processing routes. By varying the recycle cut point, the refiner can control gasoline volume, volatility, and octane number to meet market demands. The same high efficiency for conversion of middle distillates to gasoline has been demonstrated for light straight-run, catalytic, and coker gas oils.

The emphasis in this article has been on the conversion of No. 2 oil to gasoline. The Isocracking-catalytic cracking combination also offers a means for increasing No. 2 oil without a commensurate decrease in gasoline production. Based on the East Coast refinery situation described herein, two types of operation are demonstrated in Table 9. The first case represents operation, for maximum gasoline yield, as described previously in Table 1. Light catalytic cycle oil is converted in the Isocracker with recycle of material boiling above 400° F cut point. The second case shows operation maximizing heating oil by feeding the front-end (550° F to 650° F) portion of the catalytic cracker feed to the Isocracker. The Isocracker recycles materials boiling above a 550° F cut point. Based on 39,550 bpcd of catalytic cracking feed, the Isocracker-catalytic cracker combination can vary heating oil production from 4.8 to 24.0 percent by volume with 10-psi Rvp gasoline yields of 75.1 and 62.5 percent by volume, respectively. Thus, by varying Isocracker feedstock and recycle cut point, in combination with an existing catalytic cracker, there is considerable flexibility to maximize either gasoline or heating oil production.

TABLE 13—Process Plant Investment*—Isocracking Case
East Coast Refinery—Feed: Light Cycle Oil
(8,860 Barrels per Onstream Day)

Plant:	Hydrofiner (Dollars)	Isocracker (Dollars)
1. Direct labor and material:		
A. **Reactor section:** Includes feed pump; heat exchange; charge heater; make-up hydrogen; and recycle hydrogen compressors, reactors, and flash drums	1,520,000	2,650,000
B. **Recovery section:** Includes stabilizer, depropanizer, recycle splitter, and side-cut stripper	†	1,800,000
2. Technical service expenses (Includes direct engineering, drafting, and office expenses; field engineering and inspection; process design charges)	180,000	450,000
3. Indirect field expenses (Includes erection contractor's fees, contractor's field office expense, construction equipment rental, hand-tool and consumable supplies expense, temporary lines and buildings, and utilities for construction.)	370,000	950,000
4. Catalyst and chemicals	230,000	350,000
Total process plant investment	2,300,000	6,200,000

* Refer to Table 10.
† Product stripper included in reactor section.

PROCESS EVALUATIONS

The investments estimated for the new process units required for each case are shown in Table 10. The sizes of the process plants are shown in Tables 1 and 6. Where an investment is not indicated for a unit, it is assumed the existing facilities have adequate capacity. The investment shown for the increased alkylation capacity required in the West Coast catalytic cracking case assumes the existing plant is expanded. This avoids building a small new alkylation plant.

Estimates of the offplot investments are included for each case. It is assumed surplus utilities are not available for the new projects and new facilities, such as steam boilers and cooling towers, must be provided. The offplot estimates also include provisions for feed and product tankage.

Evaluations of middle-distillate conversion in the East Coast refinery are presented in Table 11. Comparison is made between catalytic cracking and Isocracking projects. Similarly, the evaluations of conversion of light cycle oil and coker distillate in the West Coast coking refinery are shown in Table 12. The projects are evaluated in terms of their changes from the base cases.

The unit values used for determining the changes in feed costs and product realizations are listed in the two tables. The excess cutter converted to gasoline in the West Coast coking refinery study is valued as fuel oil. The effects of alternative gasoline and fuel oil values on project payouts are shown in Figure 3.

No attempt is made to evaluate additional benefits arising from improvement of Motor octane rating relative to the base cases. This benefit is apparent with each of the Isocracking cases.

The estimated operating costs for each of the new process units are itemized separately. Variations in the utility consumptions and catalyst and chemical costs

TABLE 14—Hydrofiner and Isocracker Operating Costs
East Coast Refinery—Feed: Light Cycle Oil (8,860 Barrels per Onstream Day)—90-Percent Operating Factor

Plant:	Consumption Unit	Unit Cost (Dollars)	HYDROFINER		ISOCRACKER		Total (Cents Per Barrel)
			Consumption	Cents Per Barrel	Consumption	Cents Per Barrel	
Utilities							
Fuel	Barrels per onstream day (FOE*)	2.25 per barrel	76	1.9	386	9.8	11.7
Power	Kilowatt	0.00 per kilowatt-hour	.....	.....	.....	.....	.....
Compressor	.....	.....	975	.....	3,610	.....	.....
Pumps and lights	.....	.....	300	.....	940	.....	.....
Subtotal			1,275	2.8	4,550	9.9	12.7
125-psi steam	Pounds per hour	0.47 per 1,000 lb.	.....	.....	5,800	0.7	0.7
Cooling water	Gallons per minute	0.02 per 1,000 gal.	645	0.2	4,180	1.4	1.6
Subtotal				4.9		21.8	26.7
Catalyst and chemicals	.....	.....	.....	7.8	.....	11.9	19.7
Labor—supervision, analytical, and technical service (operators per shift)	.....	.....	(1)	2.3	(2)	3.8	6.1
Maintenance:							
4 percent of onplot investment	.....	.....	.....	3.2	.....	8.5	11.7
1 percent of offplot investment	.....	.....	.....	0.8	.....	2.3	3.1
Plant overhead:							
15 percent of labor and maintenance	.....	.....	.....	0.9	.....	2.2	3.1
Property taxes and insurance:							
2½ percent of investment	.....	.....	.....	2.7	.....	7.2	9.9
Total:							
Cents per barrel	.....	.....	.....	22.6	.....	57.7	80.3
Dollars per onstream day	.....	.....	.....	2,000	.....	5,110	7,110
Dollars per calendar day	.....	.....	.....	1,800	.....	4,600	6,400

* Fuel oil equivalent.

caused by changes in feed rates or process conditions have been estimated for each of the existing process plants. These costs or credits have been totaled, and only a net value for each case is indicated in the tables.

Details of the investment and operating costs for the hydrofiner and Isocracker plants included in the East Coast refinery case are shown in Tables 13 and 14.

The relative profitabilities of the cases are indicated by the corresponding project payouts. The payout periods have been calculated on an after-tax basis, using a 52-percent income tax rate with a 10-percent straight-line depreciation allowance. Each of the cases evaluated illustrates the economic advantage of Isocracking compared with catalytic cracking. This advantage results from the ability of an Isocracker to produce higher gasoline yields from the refractory middle-distillate stocks being processed.

About the Speaker

Scott

J. W. Scott is supervisor of petroleum process development for California Research Corporation, Richmond. After receiving his B.S. degree in chemistry and engineering from the University of California, he spent five years in World War II army service. Then he joined California Research Corporation and in 1951 received his master's degree in chemical engineering from the University of California.

VERSATILITY OF THE ISOCRACKING PROCESS

Whereas the examples cited have been directed toward maximum production of gasoline by recycle Isocracking, the same plant can operate on a once-through basis. Conversions of 60 percent or higher can be used, and the bottoms after gasoline can be marketed as a high-quality diesel fuel or fractionated to produce a commercial jet component.

Operating for octane improvement, the Isocracking process can convert low-octane straight-run naphthas and paraffinic raffinates into high yields of isobutane and isopentane. Heavy catalytic, thermal, and straight-run naphthas can be Isocracked to lower boiling products for inclusion in premium gasoline.

Standard Oil Company of California's commercial Isocracker at the Richmond refinery has been utilized for:

- Octane improvement feeding heavy naphthas, and
- Fuel oil reduction feeding catalytic cycle oils. Successful operation of the commercial Isocracker provided excellent verification of pilot plant results. This verification, plus the favorable economics illustrated herein, place Isocracking among the important refining techniques available to the petroleum industry.

Original presentation was before the American Petroleum Institute, Division of Refining, Detroit, May 12, 1960.

ACKNOWLEDGMENT

We are pleased to acknowledge the important contributions of many colleagues at the California Research Corporation to the development of the Isocracking process.

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[1]David H. Stormont, "New Process Has Big Possibilities," *Oil Gas J.* 57 [44] 48-9 (1959).

[2]"New Hydrocracking Process Announced," PETROLEUM REFINER 38 [11] 376-9 (1959).

A SPECIAL REPORT

WASTE DISPOSAL SESSION

How Pollution Control Builds Good Public Relations

Here's how Cities Service benefits from its $3 million investment in refinery pollution control facilities

John D. Frame
Cities Service Research and Development Co.
New York City

CITIES SERVICE COMPANY believes that, under certain circumstances, refinery pollution control can have a payout. Further, this is being demonstrated at our new refinery in Trafalgar Township in Ontario, Canada. At this new refinery, pollution control facilities represent the most modern, and the most complete waste treatment plant ever installed in a refinery.

The real advancement in pollution control stems from the adoption of a philosophy by management. The philosophy itself is not new, but its application to pollution is very new. It can be summed up in very few words: "If you can't beat them, join them!" Early in the planning of this refinery, management decided that it could not afford "to beat them." Since our company markets products in one of the most highly competitive industries in the world, it goes without saying that we must have public goodwill before the public will accept our products. Thus, it will be understood why we decided to spend approximately $3 million on refinery pollution control facilities.

Selecting a Site. The selection of a site for a refinery is influenced by many factors. These include, marketing areas, transportation, labor for construction and operation, raw materials, taxes and a good water supply. The site in Trafalgar Township met all these requirements.

Local Opposition. Because of its many advantages, it was finally decided that this was the best possible site upon which to build a refinery. Unfortunately, a sizable number of the local residents did not seem to agree with us. And, because it was necessary to have this site rezoned from agriculture to heavy industry, these people had many opportunities to publicly voice their disapproval. Although the area was zoned for agriculture, most of the local residents were "gentlemen farmers" or people who commuted to Hamilton or Toronto and had spacious homes in this vicinity. In addition, the lake front area selected for the cooling water source, was used extensively for recreational purposes during the summer months.

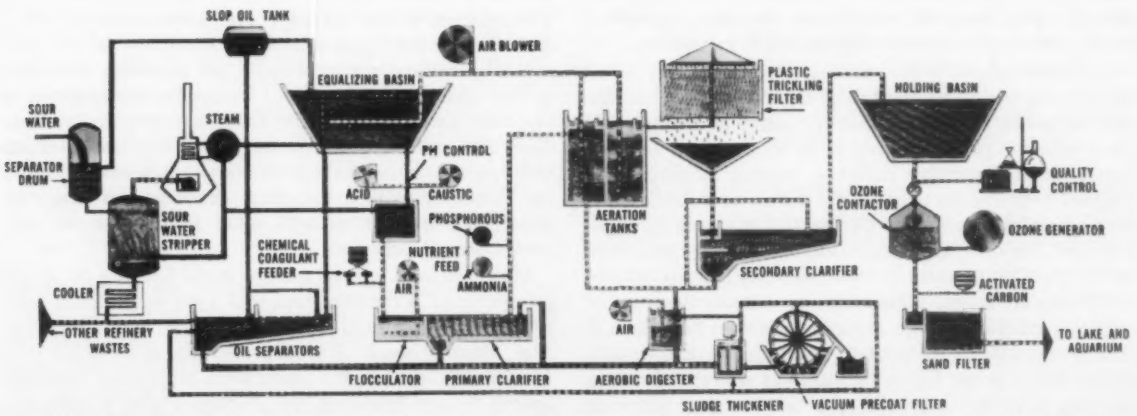

FIGURE 1—Unique in this treatment scheme is a plastic trickling filter, ozone contactor and activated carbon filter.

The vote in favor of rezoning was 4 to 3 by the three different planning boards and indicated that the new refinery was not being welcomed with open arms. Because of the publicity during these hearings, and also because the company was truly interested in establishing itself as a good neighbor, it was agreed to supply many things in the way of facilities, design, construction and the operation and maintenance of this refinery which generally are not agreed to. Most of these innovations fell into three categories: prevention of air pollution, prevention of water pollution, and preservation of the area's natural beauty.

Prevention of Air Pollution. The most modern types of equipment were installed to prevent the emission of particulate matter. The latest type of smokeless flare was constructed. Stacks on all units were raised much higher than normal. The inlet section of the oil-water separators were hooded to reduce the amount of hydrocarbons being evaporated.

Prevention of Water Pollution. It was agreed to install facilities guaranteed to produce a refinery effluent which would meet in every way the Ontario Water Resources Commission's suggested standards for effluent quality. The standards entailed some of the most stringent requirements ever encountered. For example, the suggested standards called for the effluent to contain not more than 15 ppb of phenols. Agreeing to meet these standards, was an agreement to spend approximately $1½ million, since this is the approximate figure required to reduce the phenol content from say ½ ppm down to 15 ppb.

Preservation of Natural Resources. To preserve the natural beauty of the area, it was agreed to wherever possible to maintain existing trees. Where this was not possible, the area would be relandscaped. To obtain the necessary land at the lake front for a water-pumping station, it was agreed that the pumping station itself would not rise more than 18 inches above ground level. This meant a subsurface pumping station. Also, it was agreed that this lake front area would be landscaped, planted and maintained as a park area. Thus, the company, in obtaining the necessary rezoning, agreed to many items which represented a sizable investment.

As management looked further into the future when the refinery would be operating, it became apparent that this remarkably designed refinery could be used to aid the marketing program. One of its most unique features would be the extensive pollution control facilities—this coupled with the fact that a great deal of publicity had been given the company during the rezoning struggle, plus the fact that Canadians are much more aware of the value of their natural resources than perhaps others. With this in mind, Cities Service management asked what it would cost to go even further than had initially been contemplated in order to dramatically demonstrate to the public what Cities Service was actually doing in the way of preventing pollution both of the atmosphere and the Lake.

Since effluent treating facilities were to be installed which would turn out water essentially fit for human consumption, it was decided to install a very attractive aquarium and stock this aquarium with various types of fish common to the Great Lakes area. The public would be invited to view the treatment facilities, see the fish swimming around in the effluent, and to actually see the effluent itself. This seemed the best way of demonstrating to the public the compliance of the company to the specifications agreed to for rezoning the area. A further extension of this plan evolved in connection with the park area adjacent to the Lake front. The road which runs along the Lake front is very heavily traveled and an attractive fountain using effluent water, which could be illuminated at night, might encourage the public to stop and use the park. Thus, in still another way, dramatize our position in the field of conservation.

In view of the dollars being spent on the basic facilities in the refinery, the additional cost of building the aquarium and fountain could be justified on the basis of creating public good will and increasing acceptance of the company's products. At the same time the company planned to adopt the theme of conversation which would be publicized through personal appearances of company personnel and through dissemination of material to the local press and to consumer publications.

WASTE TREATMENT PLANT

The decision to install both the aquarium and the fountain did not materially change the problem of designing the waste treatment plant. The only additional requirements were provisions to insure a continuity in the operation of the waste treatment plant. Most waste treatment plants will occasionally be upset and the effluent quality will deteriorate. Because, of invited public inspection and publicity for both the aquarium and fountain, upsets in treatment could not be tolerated which would result in shutting off the aquarium or fountain. Therefore, the volume of waste to be treated would be kept to an absolute minimum.

Recirculated Water System. Keeping waste streams to a minimum required a recirculated water system within the refinery, in spite of the excellent source of water from the lake. In addition to this, water is re-used throughout the refinery wherever possible.

Sewer System. There are seven different waste collection systems in the refinery. The seven systems permit flexibility in the operation of the waste treatment plant and also reduce the probability of receiving materials at the waste treatment plant in such concentrations as to cause operational upsets. There are systems for handling the following materials: processed water, storm water, tetraethyllead, spent caustic, tank bottoms, drainage from tank dikes and sheet drainage. In many respects, the waste treatment plant is conventional and uses standard processes.

However, one unique feature is the housing of all the process units. Primarily, this was done to facilitate temperature control of the biological treatment facilities. Also, housing would improve operator supervision over what it would be if the units were all outside. Another unique feature has been the employment of a comparatively new material for the trickling filter media. This

material permits filters up to 20 feet in depth; less tendency for mechanical plugging frequently encountered in conventional rack-type filter.

Chemical Oxidation. Because of the extremely high requirements set for effluent quality, it was necessary to utilize chemical oxidation—through ozonation—of the residual phenols following biological treatment. In biological treatment it is difficult to reduce phenol concentration much below one-half ppm. Since the goal was 15 ppb, ozone treatment was also added and facilities provided for the addition of activated carbon. This latter facility would be used to brighten and decolorize the aquarium water, and in the event the ozone equipment failed to do the job required, activated carbon dosage could be increased to maintain the effluent quality.

Public Approval. In an effort to demonstrate a good neighbor policy, not only have the effluent treatment facilities and the fountain been beautifully landscaped, but other portions of the refinery have been carefully landscaped and properly maintained. With these facilities at their disposal, the public relations people developed a continuing program for enhancing the values which have been built into this refinery.

In support of the program, more than 56,000 people have actually stopped at the fountain park since it went into operation. Also, more than 11,000 people have visited the refinery and the aquarium. The company has embarked on an active program of sponsoring speakers for group meetings at which various phases of conservation are discussed. There appears to have been a ready public acceptance of the conservation theme. The Federation of Ontario Naturalists named Cities Service Oil Company Limited as the 1959 winner of an award for conservation practices.

THE PAYOUT

Can refinery pollution control have a payout? In the usual sense of the word, the answer would have to be "no." However, with both water and air pollution control facilities as the basic units in an over-all program for better public relations, the following have been accomplished:

1. Greater and wider public acceptance of company products, evidenced by the fact that product sales in Canada have shown substantial increase since the refinery went into operation.

2. Greater percentage increase in volume sales anywhere in the company.

It is difficult to determine just how much of these spectacular increases can be attributed to the extensive water treatment facilities and the fountain at the lake. It is undoubtedly true that the presence of the refinery in the area would in itself have an effect upon the sales of products in the relatively immediate areas. Cities Service has established itself in the Trafalagar area as welcome citizens and good neighbors. Throughout the company, it is believed that although in actual dollars spent and dollars returned to date, the effluent pollution control facilities have not paid for themselves by a long shot. Nevertheless, the pollution control facilities are proving in their own way to be an asset rather than a liability. ("Can Refinery Pollution Have a Payout?" J. D. Frame, Cities Service Research and Development Co., New York, N. Y.)

About the Speaker

Dr. J. D. Frame is director of pollution control with Cities Service Research and Development Company. He received a B.S. degree in civil engineering from Norwich University in 1948 and an M.S. and Ph.D. from Massachusetts Institute of Technology in 1949 and 1951. He was director of research for Metcalf and Eddy before becoming sales engineer for F. S. Gibbs, Inc. After leaving F. S. Gibbs he joined Hydrotechnic Corp. He came to Cities Service from Hydrotechnic Corp.

More About Waste Disposal

Waste Disposal Manual: By considering some hypothetical waste disposal problems, which are typical of those facing the refining industry, the information available in the manual is highlighted. The many ways in which the manual can be of value, not only to the engineer working on specific waste disposal problems but to refinery executives and supervisors as well, are also emphasized by the hypothetical problem approach. ("API Manual on Disposal of Refinery Wastes—What It Is and What It Can Do for You," S. O. Brady, Humble Oil & Refining Co., Humble Division, Baytown, Texas.)

Air Flotation for Atlantic: Pilot unit studies indicated that combining process and sanitary waste into a single industrial waste was best for Atlantic's Philadelphia refinery. Using a first stage covered preskimmer and an API oil separator reduced vapor losses. The second stage involves chemical-flocculation-controlled neutralization and air flotation. These facilities are expected to remove 97 percent of the oil, 75 percent of the suspended solids, and to reduce both the chemical and biological oxygen demand by 80 percent. Storm water, as well as dry-weather flow, will be handled in this plant without the use of an impounding basin. ("Atlantic Selects Air Flotation for Refinery Waste," E. R. Roth, J. D. Helwig and W. A. Hall, The Atlantic Refining Co., Philadelphia.)

Texaco Treats Wastes: Using a two-sewer system and modern waste disposal facilities, an effluent which more than meets the pollution control requirements is produced. Essential features of the system are a separator, chemical coagulation equipment, biological oxidation for phenol, inceneration of sludge, retention ponds, and storage ponds to hold the effluent for final discharge. ("Waste Water Treatment at Texaco's Puget Sound Refinery," J. J. Samsel and E. A. Hawkins, Texaco, Inc., New York City and Anacortes, Wash.)

A SPECIAL REPORT

TUBING SESSION

Cut Downtime Through Onstream Radiographic Inspection

This technique gives refiners the opportunity for visual inspection of the equipment internals while the unit is in operation

L. A. White, Standard Oil Company (Indiana), Whiting, Ind.

T. Arnesen, Sarnia Inspection Co., Sarnia, Ontario

RADIOGRAPHIC ONSTREAM INSPECTION techniques reduce refinery unit downtime, operational hazards, and man-hour costs. It can be used on hot insulated equipment and it provides a visual story of equipment internals, which would be inaccessible to all other onstream inspection devices. Other onstream inspection methods require the removal and replacement of equipment insulation and sheet metal covering.

Radiographic methods can be used to determine tower tray positions and extent or amount of deposits, which tend to cause blockage in refinery equipment. Special radiographic techniques can determine thickness of the equipment wall, thickness of scale and coke, and depth of corrosion.

Refinery operators, provided with this visual proof of the exact internal condition of operating equipment, can prolong refinery unit runs as well as plan and schedule equipment turnarounds. At the same time, the possibility of serious fires and explosions is materially reduced.

Measuring Wall Thickness. The actual wall thickness can be calculated easily by means of the similar triangles indicated in Figure 1. The position of the source and the film can be altered to fit almost any situation, and the wall thickness can be calculated by the use of appropriate trigonometric functions. In some cases on insulated lines, it will be necessary to apply a correction factor.

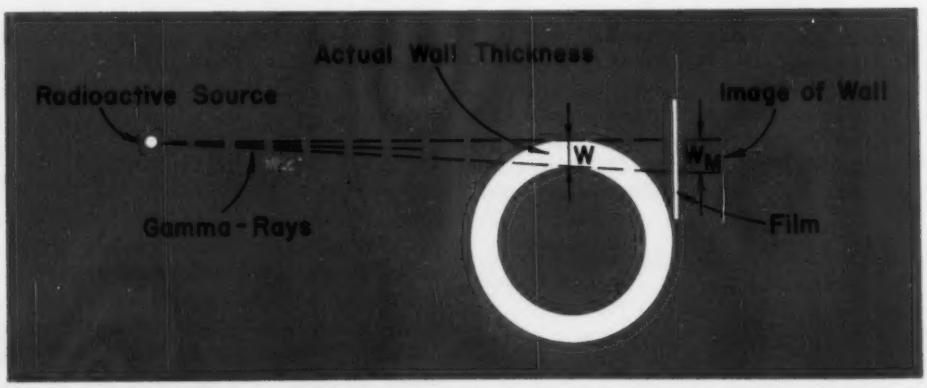

FIGURE 1—Measuring wall thickness is simply a matter of comparing similar triangles.

The image of the wall is recorded clearly on the film because the gamma rays must pass through more metal at this section than at any other point. More gamma rays are absorbed by this section and, hence, less are available for exposing the film. The image of the wall appears lighter than the remainder of the radiograph.

The approximate length of the longest chord that the rays must penetrate is 2½ inches on 6-inch. Schedule 40 pipe and 4½ inches on 12-inch Schedule 40 pipe.

Iridium 192 and cobalt 60 are the radioisotopes most commonly used. Iridium 192 can be used for obtaining thicknesses of any size pipe up through 6-inch. Cobalt 60 has more latitude and can be used for any size pipe. However, iridium 192 is considerably more portable than cobalt 60 because of the large amount of lead shielding required for most cobalt 60 storage containers.

Unsafe to Continue Operation. Figure 2 is a radiograph illustrating that it would have been unsafe to continue operation of the equipment. By the use of the radiograph, the minimum thickness of this catalytic reformer line was calculated to be 0.09 inch. As a result, the operators terminated unit operation. The sheet metal covering and insulation was removed from the line. An ultrasonic instrument, used to measure the thin locations revealed on the radiograph, indicated that the line was 0.15 inch thick. Then a radiation-type instrument was used, and it indicated that the minimum thickness was 0.19 inch. No doubt it was recording the thickness of steel plus most of the scale thickness. Subsequently, the line was disassembled and sawed into sections. The correct thickness was then found to be 0.09 inch, which exactly verified the radiographic findings. It is obvious that the discovery of a thin line, such as the one shown in Figure 2, can prevent serious fires and explosions. One finding of this nature will save enough money to pay for a radiographic inspection program for many years.

Corroded Equipment. Radiographic inspection may reveal that equipment is corroded and may soon reach an unsafe condition. As a result, replacement equipment may be fabricated, purchased, or otherwise procured before the equipment is shut down. This can prevent unscheduled shutdowns and shorten downtime. In many cases it will only be necessary to operate on bypass or to depressure for a few hours while replacement equipment is being installed. Figure 3 and 4 illustrate two examples of dead-end corrosion.

The lower end of a gas pull header was radiographed for possible dead-end corrosion. The radiograph revealed that the small drain nipple was thin. Note that someone had left a stud bolt inside the pipe.

Inaccessible Internals. Equipment internals are not accessible to normal inspection devices, but radiographic inspection can be used to determine their condition. This is illustrated in Figure 5. An internal 2-inch pipe elbow is used to streamline the flow and prevent turbulence in the main line. The sketch is typical of eight identical alkylation acid-oil emulsion lines. On several occasions in the past, this elbow has corroded away. When this happens, it is a very short time until the 10-inch line

FIGURE 2—The inside surface of this pipe is corroded with iron sulfide scale which indicates that it is unsafe to continue operation.

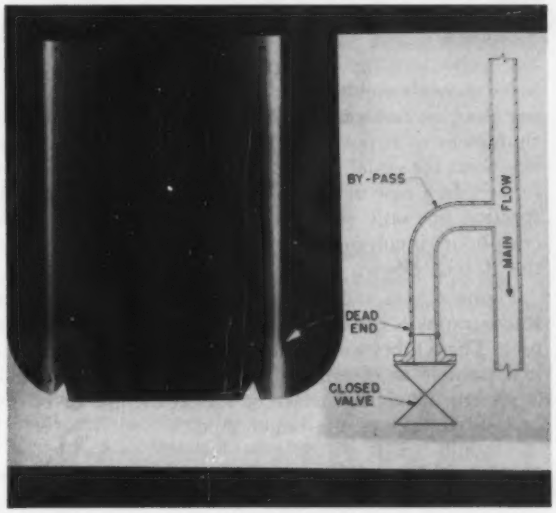

FIGURE 3—Sketch shows where radiograph was taken of dead-end corrosion.

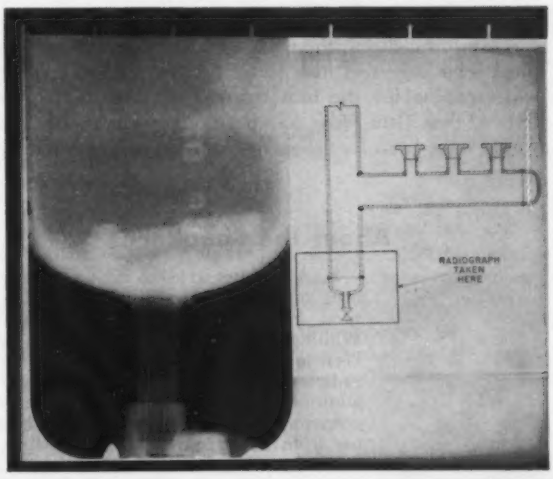

FIGURE 4—Gas pull radiograph shows drain nipple to be too thin. Note old stud bolt left inside pipe.

AN API SPECIAL REPORT
Onstream Radiographic Inspection

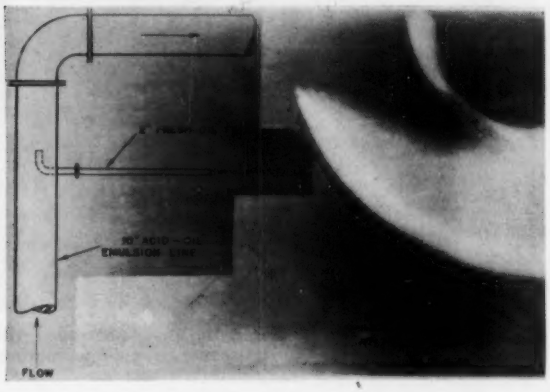

FIGURE 5—Radiograph checks on condition of internal elbow.

holes through opposite the 2-inch inlet. Therefore, during the past few years, it has been our practice during shutdowns to remove the 10-inch elbows directly above this point for visual inspection to forestall their complete failure. In a case of this type, onstream radiographic inspection not only saves downtime but also saves the craft-hours involved in the removal and replacement of the 10-inch elbows.

Figure 6 is a radiograph of a double-pipe cooler. Radiography is the only means of inspecting the internal tube. These tubes were in reasonably good condition, but it is possible to determine if corrosion, pitting, or scale is present on either surface of the small pipe or on the internal surface of the larger pipe.

Malfunctioning Equipment. Figure 7 is a radiograph which illustrates equipment that was not functioning properly. This globe valve was used for throttling a tower reflux stream. During normal operations, it was opened one or two revolutions of the handwheel. A unit operator reported that he could open the valve but could not close it. He requested our help. Radiographic inspection proved that the stem was disconnected from the plug. The plug was in a tilted position and enough oil was escaping for the unit to operate. This radiograph showed that if the valve had been opened more, the plug would have been forced away from the opening and full

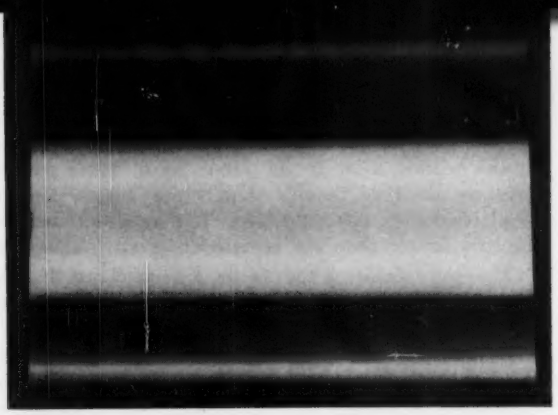

FIGURE 6—Double-pipe cooler proved to be in good condition.

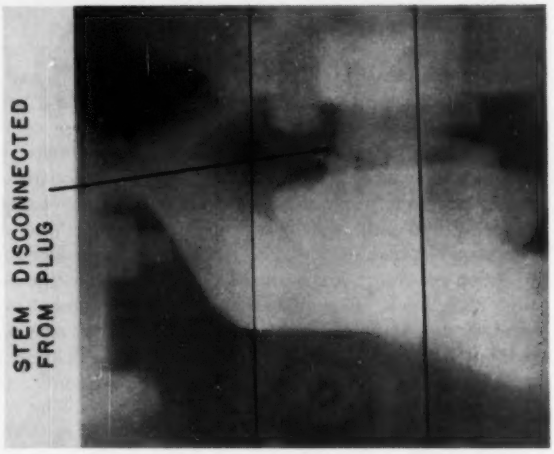

FIGURE 7—Malfunctioning globe valve. Vertical black lines overlap from three radiographs.

flow would have resulted. The excessive amount of reflux would have upset tower fractionation. Orders were given that the valve stem setting should not be disturbed. This refining unit operated with the valve plug in this position until the next scheduled shutdown.

A report that it was impossible to obtain the proper vacuum on a vacuum ejector system offered an interesting problem. Several radiographs were taken of the system. One radiograph disclosed that the diffuser throat was eroded and another radiograph disclosed that the inside bore of the steam ejector nozzle was eroded. New parts were ordered and subsequently the vacuum ejector system was bypassed while replacements were installed.

Cost Savings. It is difficult to attach an exact figure to the amount of money saved by the application of radiographic onstream inspection techniques, but it is known to be substantial.

This is particularly true when we consider fires or explosions that could have been eliminated with radiographic inspection, or fires or explosions, or both, that we believe did not happen because of radiographic onstream inspection.

Downtime days may be valued for a few thousand dollars to several times that amount depending upon supply, demand, refinery integration, and other factors. Radiographic onstream inspection can reduce downtime as follows:

About the Speaker

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1. Runs can be prolonged and some unscheduled shutdowns can be eliminated.

2. Prefabrication of replacement piping and the like can be accomplished prior to the shutdown.

3. Manpower, which otherwise would have been used for removing insulation and sheet metal covering and for breaking flanges for inspection during the turnaround, is available for other shutdown work.

One cost which can be determined is the removal and replacement of insulation and sheet metal covering for other inspection methods. This is estimated to be $10 to $20 for each point inspected. This one saving will pay for the radiographic inspection program. Longer runs, shortened turnarounds, and all the other advantages are extra dividends.

Originally presented to the API Division of Refining meeting, Detroit, May 10, 1960. ##

More About Tubing

PREDICTABILITY is one major contribution that an inspection department offers to the refinery. Statistical concepts improved predictability when applied to Sohio refineries' inspection data. Such concepts have placed a new emphasis on the importance of inspection data procurement and its evaluation.

About 1954, Sohio inspection engineers became convinced that statistical methods had potential for saving time and money if properly applied to refinery inspection work. Continued development has been rewarding particularly in the following areas:

- Thickness variability in new piping and steel plate has been determined for future use in corrosion rate analyses.
- On piping circuits it was possible to obtain thickness measurements by sound sampling procedures and infer the condition of entire systems. The recent development of onstream radiographic inspection has made this type of statistical evaluation of data even more useful and important.
- Thickness readings on tanks and vessels, when properly sampled, yielded more useful information than spot checks at established inspection locations.
- Inspection of each and every furnace tube in a circuit was found to be unnecessary, and corrosion rates of furnace tubes were put on control charts.
- Presentations of recommendations to management have been more acceptable, factual, and the risks more accurately stated. Consequently, better and faster decisions have been made.
- Safer and more economical maintenance planning was the ultimate result of the effort.

Pipe. Spot checks on new pipe shipments can be made in a minimum amount of time and, when needed, an original minimum measurement could be recorded as follows:

1. Under 0.30-inch thickness, use nominal wall thickness for 2-inch, Schedule 80 pipe and 3-inch to 6-inch, Schedule 40 pipe.

2. Over 0.30-inch nominal and up to 0.50-inch wall thickness, reduce the recorded wall thickness by 1/64 inch to 1/32 inch depending upon the risks involved for the particular service conditions.

Steel Plate. In general, the following specific conclusions reached on new ⅜-inch plate would be somewhat similar to other plates studied above ¼ inch in thickness:

1. The best estimate of the average thickness for ⅜-inch plate was 0.019 inch higher than the nominal thickness.

2. Only 7 times out of 100 would nominal thickness (or less) be measured.

3. Measurements exceeding 0.050 inch above nominal were frequently recorded.

4. Inspection conclusions regarding condition of vessels or corrosion rates would be highly subject to error if based only on nominal thickness and a few fixed test locations.

Crude Furnace Outlet Lines. This study revealed the following information:

- Standard deviation of the pipe wall thickness when new, in 1952, was ± 0.011 inch. Corrosion had caused this to increase to approximately ± 0.068 inch in seven years.
- The maximum seven-year corrosion rate was 0.047 ipy (0.48 inch to 0.15 inch). However, even after seven years, some locations remained at original thickness. Therefore, all corrosion rates existed in this piping system, from zero to 0.047 ipy. Distribution of these rates would correspond exactly to the distribution of thickness measurements.
- Originally the established inspection locations were inadequate for the corrosion encountered. However, at a very low cost, approximately $350 for 26 radiographs, the condition of the lines was well established. Caliper measurements verified the importance of sampling technique in this problem.
- Radiograph data showed that the No. 2 unit was the immediate problem and pointed the way to proper maintenance planning.
- Statistical knowledge of data procurement and evaluation relieved the uncertainty and guess work usually accompanying this type of refinery situation. Inspectors knew exactly what to recommend and why. Only a minimum of discussion and explanation to plant management was necessary to start the replacement planning activity.

Tank Corrosion. Two tank corrosion studies were undertaken at the Lima refinery using statistical methods for data acquisition and analysis. One was initiated because of general corrosion in gasoline tanks reported by others in the industry. The other study resulted from

heavy corrosion visually observed in catalytic reformer naphtha feed tanks at Lima.

- Statistical tests proved, what was apparent by observation, that no significant difference existed between the sample distributions and the best estimate of original distribution for the top three courses. Corrosion was not significantly active.
- The bottom four courses all show a significant amount of corrosion.
- Comparing courses 1, 2, 3, and 4, it was found that course No. 4 was corroding at a slower rate than the bottom three courses.
- No difference could be established at the significance level of 95 percent used in this study for the bottom three courses. However, the higher rate indicated at course No. 3 is a more practical estimate of this loss than the three-course average if the high-confidence level is not demanded.

Naphtha Tanks. The most damaging corrosion was found in the upper three courses of the naphtha tanks where the mean thickness will reach the practical limit within 6 to 9 years.

- The lower naphtha tank courses, limited only by design filling limits, have a remaining life of at least 20 years.
- The gasoline tanks with negligible corrosion in the limiting upper areas have an expected life of at least 25 years more. ("Sohio Inspectors Apply Statistical Methods," W. P. Shontz, The Standard Oil Co. (Ohio), Cleveland, Ohio, W. W. McDaniel and R. R. Decker, The Standard Oil Co., Lima, Ohio.)

Find Tube Wall Temperature and Prolong Life: The reliable measurement of tube wall temperatures is important in prolonging tube life by preventing overheating. Accurate and reliable tube wall temperature measurements enable the operator to adjust operating conditions to keep below maximum allowable temperatures and at the same time obtain the maximum possible throughput in spite of tube fouling.

Installation Points. The number of thermocouples which are placed in a heater depends on its size, flow arrangement, type of service, and general configuration. Naturally, there is an economic limit and, therefore, thermocouples are installed only on the hottest tubes. At our Marcus Hook refinery, large multicoil heaters have as many as 20 installation points and small heaters have as few as four installation points.

Care should be taken to pattern the installation points in a manner which would permit detection of hot spots. For example, if a horizontal tube heater has an effective tube length of 40 feet, the installation points should be at approximately 8-foot intervals between tube sheets. It would be erroneous to place all the thermocouples at, say, 20 feet from the tube sheets because the furnace could be fired in such a manner as to be much hotter at the ends than in the center and tubes could become overheated without detection.

Probably the most important factor to consider in selecting installation points is the fouling pattern, for those tubes which become most heavily fouled are generally the hottest in the furnace unless they are located in the convection section. In a new heater, it is not easy to predict exactly what this pattern will be because it depends on the nature of the charge stock, as well as heater configuration, and predictions sometimes go amiss.

In crude oil heaters, we have found that the hottest tubes are generally located near the point where vaporization begins. Fouling is generally heaviest in these tubes, particularly when charging crude oil which is not desalted. In most other heaters, the thermocouples are placed on tubes near the outlet or on tubes near the burners where the heat flux is highest.

New Thermocouples Prove Successful. The introduction of metal-sheathed thermocouples, insulated with magnesium oxide, gave us a new tool to work with. In such a thermocouple, the sheath protects the wires from destruction by the heater atmosphere and yet the assembly is not so large as to cause substantial temperature error as a result of conduction of heat from the hot gases to the tube wall through the thermocouple assembly. Furthermore, they are more flexible than the No. 8 gage bare-wire thermocouples, are less susceptible to destruction from vibration, and are easier to handle.

The attachment block is 7/16 in. by 7/16 in. by 3 in. in size and is made of the same metal as the heater tubes. Two holes are drilled through the block at an angle of 30° for the insertion of the thermocouple. The two holes enable us to replace the thermocouple at least once without the necessity of welding a new block on the tube. This is important with alloy tubes as the stress relieving required after welding is both expensive and time consuming.

The thermocouple is inserted in the hole in the block and peened tight after the block has been welded on the tube. The thermocouple is then held firmly to the tube with stainless steel bands and brought out through the heater wall at the nearest possible point. High nickel, low chromium thermocouples with a 3/16-in. diameter, Type 309 stainless steel sheath have given us excellent results. The average life is more than one year, with some thermocouples lasting as long as three years. Our tests indicate that these thermocouples are accurate to approximately ±15° F.

Problems. Many of our initial problems were caused by failure of the stainless steel sheath material. This difficulty has been almost entirely eliminated by changing the outside diameter of the sheath from 1/8 inch to 3/16 inch, with a corresponding increase in wall thickness, and by changing the sheath material from Type 316 to Type 309 or Type 310 stainless steel.

We are not satisfied that thermocouples are the ultimate method of determining tube wall temperatures because at best they only indicate spot readings. Possibly some method of optically scanning the entire surface of every tube could be devised by the use of thermistors with suitable filters to eliminate the effects of the hot gases and refractory surrounding the tubes. ("The Techniques and Significance of Measuring Tube Wall Temperatures in Heaters in Service," F. S. Becker and F. M. Kepler, Sun Oil Co., Marcus Hook, Pa.)

MOTOR GASOLINE SESSION

Future Gasoline--What's Needed

Now The Refiner is obliged to consider more carefully the effect of fuel composition on a number of noise-producing combustion irregularities. For example, fuel components such as aromatics are very effective in reducing knock. However, at higher compression ratios, some cars show these materials to be quite ineffective in reducing surface ignition and rumble. Thus an extensive program was started to make a closer determination of car performance on the road.

The study includes a look at fuel components, finished fuels, and a few pure hydrocarbons in terms of part-throttle and full-throttle knock, surface ignition and rumble. More than 100 fuels were road rated in standard and experimental high-compression-ratio cars. The fuels range in quality from present-day premium gasolines to special high-octane components and blends for future gasolines. Specific comparisons are made of a wide variety of reformates, pure aromatic, and light paraffinic materials.

A comparison of the incidence of surface ignition is made between highly aromatic and highly paraffinic fuels. The data were obtained with a newly developed instrument for measuring both total surface ignition and rumble in unmodified engines. A number of fuels were evaluated in the presence of their own deposits laid down under mixed-duty driving conditions. Also, the surface ignition tendency of a wide variety of fuels was determined in these same cars using a common combustion chamber deposit composition for all fuels.

The results of all the antiknock studies and the surface ignition investigations are related now in such a way as to aid refiners in selecting future processing methods to achieve maximum fuel quality at minimum cost. ("Combustion Qualities of Future Gasolines," W. E. Morris and K. Hyatt, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.)

Other Sessions Abstracted Here

- **Power Fuels**
- **Hydrocarbons, Autos and Clean Air**
- **Analytical Research**
- **Operating Practices**
- **Lubricants**

How Knock Ratings Go Wrong: Several variables might logically be limiting the reproducibility of laboratory octane ratings above 100. Some of the variables which have been investigated include: (1) the effects of operating at the extremes of the tolerances permitted by the ASTM test procedure, (2) engine and combustion chamber effects, and (3) instrumentation effects. These variables have been studied in terms of changes in rating for commercial type fuels. ("Some Sources of Error in Laboratory Knock Ratings," W. E. Adams and J. D. McCullough, Ethyl Corp., Detroit.)

POWER FUEL SESSION

Outlook for Auto Gas Turbine

Research and development in the field of automotive gas turbines over the past few years has resulted in vehicle installations of regenerative turbine power plants which are competitive with automotive spark-ignition engines from the standpoint of specific fuel consumption, control, agility, and noise. The turbine is considered to be superior to the reciprocating engine in smoothness, ease of cold weather starting, lack of sensitivity to certain fuel characteristics, weight, space occupied, simplicity, maintainability, and future development possibilities.

Yet to be proven are economic factors such as turbine costs compared to reciprocating engine costs under large volume production, and the comparable costs of tooling for large volume production. Analyses have been made of the future potentialities of the turbine from an engineering standpoint and these have been related to probable use in competition with reciprocating and other types of engines. ("The Outlook for the Automotive Gas Turbine," G. J. Huebner, Jr., Chrysler Corp., Detroit.)

Fuels for Military's Diesel: Early postwar actions were taken to standardize on the use of gasoline for most army equipment. Conditions then brought about a recent decision to use compression-ignition (diesel) engines over a wide range of power outputs. Thus possible wartime demands on the middle distillate portion of the barrel of crude oil has prompted investigation of compression-ignition gasoline-burning engines. One engine is now

being field-tested and several others are under investigation.

For combat equipment, compression-ignition engines using the proposed Mil-F-45121A (Fuel Oil, C.I., Referee Grade) are being developed. This wide-cut fuel, being a mixture of approximately 50 percent gasoline and 50 percent distillates, helps stretch the distillate portion of the barrel of crude oil.

Problems are being encountered with both engines and fuels. It is believed the engine problems will yield to development. Certain limitations may have to be placed on the composition of either gasoline or the compression-ignition fuel. It is not expected that these limitations will seriously affect supply under wartime conditions. ("The Military Mission of the Multifuel Compression-Ignition Engine, and Its Fuel Requirements," E. J. Gay, Consultant, Detroit.)

Good Aircraft Turbine Fuel. Paraffinic-type hydrocarbon fuels minimize many of the problems being experienced in the operation of aircraft gas turbine engines and merit consideration as premium-quality fuels. Their flame radiation, exhaust smoke and odor, thermal stability, heat content and low-temperature characteristics are compared to those of JP-4, kerosine, and other fuels as they are related to service problems. ("Premium-Quality Fuels for Aircraft Turbine Engines," N. P. Randall, R. J. Pecora, R. Y. Heisler and Stephen Hopkins, Texaco, Inc., Beacon, N. Y.)

HYDROCARBONS, AUTOS AND CLEAN AIR SESSION

How Goes Air Pollution

RESEARCH HAS SHOWN which of the materials commonly found in gasoline tend to produce olefins that are emitted in the engine's exhaust. Further, car operation—acceleration, deceleration, and the like—affects the balance between olefins in the fuel and those that appear in the exhaust. Conclusion is that the problem of smog reduction is much more complex than simply removing olefins from gasolines. Other fuel factors and the way in which cars are driven must also be considered. ("Do Automobile Emissions Inherit Fuel Characteristics?" R. W. Hurn, T. V. Davis, and Pearl E. Tribble, Bureau of Mines, U. S. Department of the Interior, Bartlesville, Okla.).

Carburetor Vapor Losses: A study has established that gasoline vapors, escaping from carburetors of motor vehicles is a source of air pollution. Vent losses are relatively minor and can be eliminated for all practical purposes. Factors affecting vent losses are—carburetor bowl temperature, fuel volatility, driving pattern and carburetor vent design. Vent losses can be reduced to nil with proper carburetor vent design and good driving patterns. While additional studies must be made before arriving at definite conclusions, it appears that carburetor design offers the best point of immediate attack. ("Factors Affecting Carburetor Vapor Losses," W. F. Deeter and R. G. Jewell, Richfield Oil Corp., Anaheim, Calif.)

Exhaust Afterburner Status: While they soon may be required by California law, their development is still fluid. With three general types under active development—low and high-temperature catalytic and direct-flame—it appears that the catalytic approach, if perfected, could be the ultimate answer to the exhaust problem. Each type has its particular problems and perhaps there will be a market for both general types. ("Status of Motor Vehicle Exhaust Afterburners," W. L. Faith, Air Pollution Foundation, San Marino, Calif.)

Compound X: At last identified as peroxyacetyl nitrate, a highly oxidized, unstable organic nitrogen compound. Formed by irradiation of simple olefins and nitrogen, the compound has been purified and its chemical, physical and physiological properties examined. It produces plant damage in concentrations well below 1 ppm and is a strong eye irritant in the parts-per-million range. ("Photochemical Reaction Products in Air Pollution," E. R. Stephens, E. F. Darley, O. C. Taylor, University of California, Riverside, Calif., and W. E. Scott, W. E. Scott and Associates, Perkasie, Pa.)

ANALYTICAL RESEARCH SESSION

Better Tests

ELECTRON MICROSCOPY, light scattering, and polargraphy have been applied to the study of oil stability and compared with the more usual sludge-weight and visual-rating techniques.

Concurrent examinations of aged fuel oils by light scattering and electron microscopy were used to determine the significance of light scattering values with respect to actual particle morphology. Sludging characteristics of oils in the transformer range were studied, using polargraphy to follow the formation of the peroxide and aldehyde precursors of sludge and using light scattering and electron microscopy to follow sludging in its early stages. The three techniques described are complimentary and when applied concurrently are extremely useful for giving a more complete understanding of stability problems in oils. ("Use of Light Scattering, Electron Microscopy, and Polargraphy in Oil Stability Studies," J. W. Loveland, G. R. Dimeler and L. G. Bostwick, Sun Oil Co., Marcus Hook, Pa., and L. J. Cali, Callery Chemical Co., Callery, Pa.)

Distillation of Chromatography. Gas liquid chromatograph allows one to obtain, in less than an hour, distillation curves as good as those by very time-consuming conventional analytical precision distillations. Thus the method is much superior to the ASTM D 86 method. With no more expenditure of time, it gives a better account of light and heavy ends in gasoline, because there is no loss of holdup. The method is also applicable to

materials which otherwise would require vacuum distillation. Only a few milligrams are required. "Analytical Distillation by Gas Chromatography—Programmed Temperature Operation," F. T. Eggertsen, Sigurd Groennings and J. J. Holst, Shell Development Co., Emeryville, Calif.)

Crankcase Oils. An apparatus has been developed to simultaneously measure both the fuel and water present in used crankcase oils. It was devised primarily to speed up the testing, so that engineers could receive results more quickly. However, it was also desired to provide a direct procedure for diluent in diesel oils which is commonly determined by viscosity blending charts. Data from such charts can be very misleading if the grade of oil in question is unknown, or if the insolubles are high.

The new test is based on the principle of automatic distillation and requires only that the operator charge the sample and push a button. He can return at a convenient time to read off the water and dilution. Results correlate well with the ASTM tests for gasoline engine oils and are even more precise. Diesel fuel contamination is fully recovered so long as the fuel is of a distillate type. ("Simultaneous Measurement of Water and Fuel Contamination in Crankcase Oils by Automatic Vacuum Distillation," R. K. Siegfriedt and O. A. DeWoody, Socony Mobil Oil Co., Inc., Brooklyn, N. Y.)

Vanadium. Specific study of vanadium in residual Boscan asphaltenes was made, because here this metal is relatively concentrated. The vanadium has been found to be extremely well protected in these asphaltenes and resists any common method for removing them. It is obvious that vanadium has played a key role in the formation of these materials.

If petroleum refiners find it necessary to remove the vanadium from these residual fractions, the only technique which appears feasible would be severe hydrocracking or similar process. ("A Study of an Intrinsic Contaminant in Petroleum—The Nature of Vanadium in Asphaltenes," A. A. Wolsky and F. W. Chapman, Jr., The Atlantic Refining Co., Philadelphia.)

Oxygen and Nitrogen. An improved direct combustion method has been developed which utilizes gas chromatography to measure O_2 and N_2. A common apparatus may be used for both nitrogen and oxygen except for combustion tubes. The sensitivity is vastly improved over conventional methods; 10 ppm of either element can be determined. Only 30 minutes is required for the determination of either nitrogen or oxygen. Accuracy is within 0.1 percent of theory for both elements. ("The Determination of Nitrogen and Oxygen in Organic Materials Utilizing Gas Chromatography," R. L. Scott, D. E. Smith, J. E. Puckett, and B. J. Heinrich, Phillips Petroleum Co., Bartlesville, Okla.)

OPERATING PRACTICES SESSION

Safer Ups and Downs

GENERAL PROCEDURES are presented which should be incorporated into detailed procedures for routine shutdowns and startups to reduce the hazards and achieve safe "ups" and "downs" for refinery units. ("Safe 'Ups' and 'Downs' for Refinery Units," A. H. Hayes and R. M. Melaven, Standard Oil Co. (Indiana), Whiting, Ind.)

Crude Unit Startup: The novel feature of Gulf's procedure is that startup or shutdown proceeds by orderly steps and phases. Recirculation of products to the crude unit is practiced during startup and shutdown, and towers are started under a slightly controlled gas pressure. Circulation is established with all key pumps operating and complete dehydration is assured. The vacuum tower is brought over and vacuum applied at a controlled rate. ("Startup-Shutdown Procedures for a Large Crude Oil Distillation Unit," W. S. Bonnell and J. A. Burns, Gulf Oil Corp., Port Arthur, Texas.)

Vacuum Units: Sohio's Cleveland refinery has found it necessary to give special attention to the startup of vacuum towers and the shutdown of crude oil towers. Moisture is removed from vacuum towers with superheated steam; heavy gas oil is used to flush the tower and displace moisture from all pumping circuits.

The crude tower shutdown is also outlined; it includes furnace drying, oil washing, vapor purging, steam cooling and water washing. ("Towers Are Touch," R. W. Ballmer, The Standard Oil Co. (Ohio), Cleveland.)

LUBRICANTS SESSION

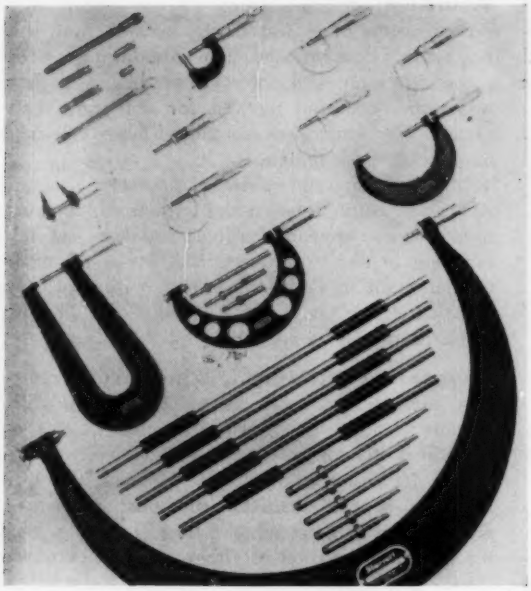
Gear Lubes Review

THE CURRENT DESIGNATION, API GL-4, was explained as to its intended field of application as an automotive gear lubricant and its acceptance to date. Further cooperative procedures between automobile and petroleum industries are suggested. ("Background and Current Status of the API GL-4 Designation for Automotive Gear Lubricants," C. R. Noll, Gulf Oil Corp., Pittsburgh.)

Chrysler GL-4 Experience: Present service recommendations for Chrysler cars include the use of GL-4 oils. It is anticipated that requirements for usage of the new gear lubricants will increase in the future. ("Chrysler Experience with GL-4," D. F. Miller, Chrysler Corp., Detroit.)

Equipment Designer's View: Progress is being made by mutual attack on problems of design by equipment and lubricant people. ("An Equipment Designer's View of Progress," F. R. L. Daley, General Motors Corp., Flint, Mich.)

Discussion. The equipment manufacturer's business is dependent upon the performance of the lubricants in his vehicle. Consequently, his needs must be considered in the formulation of gear lubricants which will provide maximum life for the equipment. ("Prepared Discussion of Session," R. K. Smith, Elco Lubricant Corp., Cleveland.)



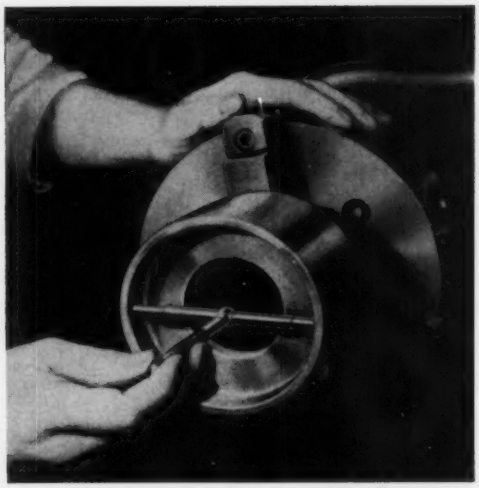
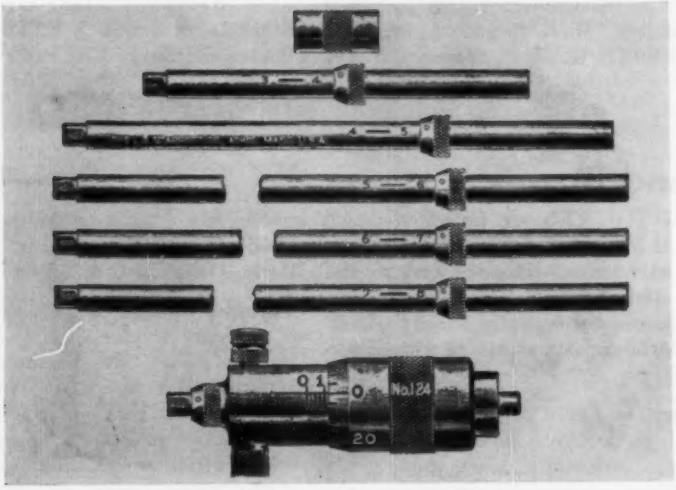


FIGURE 1—Many styles of micrometers are available . . . OD type, left; telescoping, above, and ID type, below.



Corrosion Measurement Short Course

Part 1: Inspecting Corrosion Damage

Part 2: Onstream Corrosion Measurement

Part 3: Finding the Cause of Corrosion Damage

A. J. Freedman, A. Dravnieks and B. Ostrofsky,
Standard Oil Company (Indiana), Whiting, Ind.

CORROSION is a fascinating physico-chemical process, for a corrosion researcher. For a plant corrosion engineer, it is a daily challenge. For a plant manager, it is a most unwelcome and costly nuisance. Nevertheless, corrosion has to be detected, has to be measured, and has to be kept under control. The rewards for success in this work are many: economy in materials, in equipment life, in operating factors; safety; and, frequently, a better, cleaner product.

Corrosion Measurement Aims. Corrosion measurements should indicate the rate and mode of metal loss from equipment walls to assist in predicting the progress

of damage. The measurements should assess the total amount of damage which has occurred, so that the remaining useful life span of the equipment can be predicted. Corrosion measurements also should help to determine the relative merits and efficiencies of alternative means of corrosion control, e.g., alloys, inhibitors, etc.

To live up to these many requirements, every adaptable principle of measurement has been brought into action. Weight, thickness, sonic, X-ray, gamma radiation, electrical, visual, and chemical analytical methods all are in regular use.

Techniques. Corrosion measurement techniques may be classified roughly as follows:

- Methods for inspecting corrosion damage which already has occurred in the plant.
- Methods for measuring the corrosivity of plant fluids:
  a. Directly, by measurements of corrosion on specimens exposed to the fluids in the equipment.
  b. Indirectly by measurements of some chemical or physical characteristic believed to be strongly related to the corrosivity of the fluids.
- Methods for investigating the mode and possible cause of the corrosion damage, in cases where there is some doubt as to the nature of the corrosive agent.

INSPECTING CORROSION DAMAGE

Routine inspections of refinery units are an essential part of normal refinery maintenance. In-service corrosion rates obtained by these inspections permit calculation of expected useful lives for operating equipment, and provide advance warning when replacement parts are needed. Also, service data obtained on many alloys under refinery conditions provides a background of experience to guide materials selections for new processes.

Frequent inspections are particularly important when new units are brought onstream. This is the time when materials selections are put to the test. Failure to check initial corrosion rates in sensitive locations could result in a catastrophe. However, good judgment is essential in interpreting high initial corrosion rates, since the formation of protective corrosion product scales often leads to much lower long term corrosion rates. Previous laboratory experiments often can help in determining whether or not protective scales can be expected to form.

Manual Thickness Measurements.

Hand Calipers and Micrometers. Most thickness measurements in pipe and vessels are made manually, with scale or dial-indicating calipers and micrometers. Many different styles are available, for outside and inside diameter measurements in most accessible locations. Figure 1 shows three different types of micrometer devices. Sometimes, thickness measurements in vessels or in long sections of pipe are made through caliper test holes. This method is expensive and the holes are susceptible to leaks after they are plugged and welded. In all caliper measurements, it is important to check for pitting attack by taking a number of separate measurements around the area in question. If only very small pits are present, they may be missed if the caliper tips are wider than the average pit diameter.

FIGURE 2—Depth gages help determine the corrosion rate.

Electric Tube Calipers. The electric tube caliper is a time-saving device for inspecting entire lengths of furnace tubes. The caliper consists of spring-actuated, pivoted fingers in an aluminum housing. The fingers make continuous contact with the inside tube wall and at the same time position an armature between two coils. The resulting voltage output is indicated on a meter calibrated in tube diameter. Internal diameters of any size can be measured by substitution of caliper heads. The range of each head is approximately 1.25 inches. The electric tube caliper should not be relied upon to give the exact depth of pits because the curvature of the fingers does not always permit full penetration. Also, isolated pits may be missed completely because the angle between adjacent fingers permits some straddling.

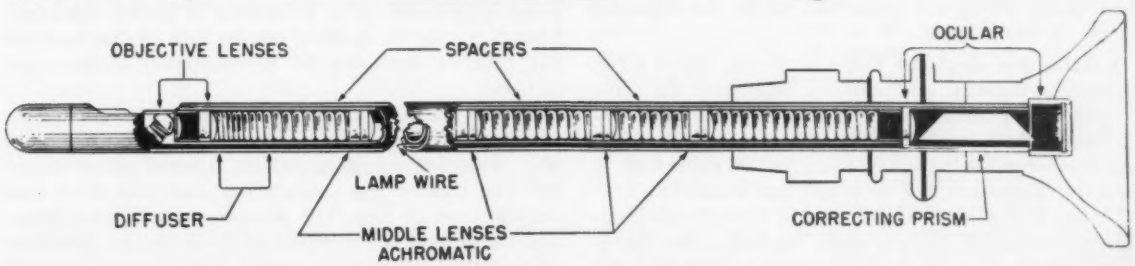


FIGURE 3—The boroscope aids in visual inspection of internal surfaces.

Bench Marks are corrosion-resistant reference points installed in vessels as an aid in determining corrosion rate. They are used in connection with an ordinary depth gage (Figure 2). These reference points usually consist of alloy buttons welded to the shell in specific locations. A standard reference bar is laid across the buttons, and the distance from the top of the bar to the vessel wall is determined with a depth gage. The change in this reading vs. time is a direct measure of the corrosion rate.

Boroscope. The boroscope is an optical instrument for the visual inspection of internal surfaces (Figure 3). It is particularly suited for examining recesses and inaccessible points without dismantling the equipment. The boroscope consists of a telescope tube, illuminator, objective lense, middle lenses and an ocular. It is possible to view directly forward and at 55°, 90°, and 140° angles from the axis of the telescope. The boroscope will fit through openings as small as 0.120 inches. Also, it may be used to inspect the internal surfaces of heat exchangers with openings 4 inches in diameter and depths to 60 feet. A flexible model is also available for examination of curved tubes.

Ultrasonic Thickness Measurements. Ultrasonic sound waves, with frequencies above 20,000 cycles per second, travel in relatively straight lines through materials. These short waves are reflected from boundaries, both at the surfaces and at discontinuities inside the material. These properties can be used to measure thicknesses of metals and to detect internal flaws.

Ultrasonic methods, sometimes combined with hammer testing, are used in refineries primarily for onstream measurements of wall thicknesses and internal failures (such as hydrogen attack), and also for offstream measurements where only one surface is accessible. This tool has made possible onstream inspection of sensitive locations, thus avoiding unnecessary shutdowns for inspections and providing advance warning when replacement parts are needed. Because of the great value of these techniques in modern refinery operation, the methods will be described in some detail.

Two basic methods of ultrasonic inspection are available: reflection and resonance. The reflection technique will measure thicknesses, and detect and locate many different types of internal flaws. The equipment needed for this method, however, is bulkier, more complicated and more expensive than that needed for resonance measurements. Resonance equipment, while simpler, is less versatile than reflection equipment. The resonance method will measure thicknesses but will detect only those flaws which are perpendicular to the direction of the ultrasonic beam.

1. Reflection Methods: When ultrasonic waves travel through a material and strike a boundary, they are, for practical purposes, stopped and reflected back. Instruments capable of sending out an ultrasonic pulse and receiving the reflected echo can be calibrated to measure thicknesses and to detect and locate flaws.

Figure 4 is a block diagram of a typical reflection-type ultrasonic thickness gage. Basically, the instrument consists of an oscillator to generate the ultrasonic radiation, plus a transducer to convert the pulse to mechanical energy for transmission through the material under test and to receive the reflected pulse. In addition, the circuit contains an amplifier to increase the amplitude of the reflected signal output from the transducer, and a means for reading out the time taken to recover the reflected signal in terms of distance.

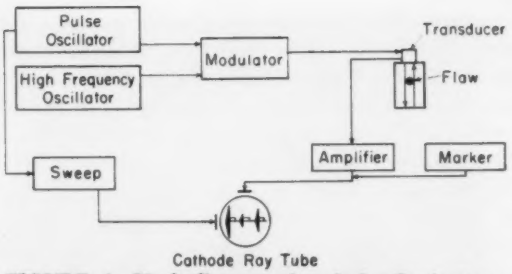


FIGURE 4—Block diagram of typical reflection-type ultrasonic thickness gage.

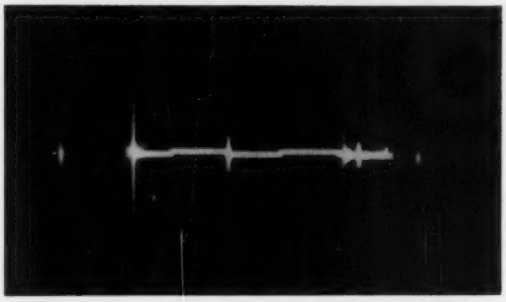
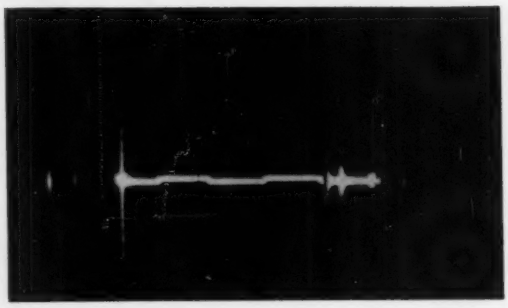


FIGURE 5—Ultrasonic measurement shows flaw near center of material in upper photo and no flaw in lower photo.



In practice, the frequency used is determined by the flaw resolution or depth of penetration required. The higher the frequency, the greater the resolution. The lower the frequency, the greater the penetration. Frequencies range from 0.2 to 25 megacycles. The instrument is calibrated with a material of known thickness. Distances may be marked on the face of the cathode ray tube or indicated by superimposed square-wave signals.

To use the instrument, the transducer is applied to a surface of the material being tested, through a suitable couplant such as glycerine, mineral oil or motor oil. The face of the cathode ray tube will show two vertical lines or pips. The first pip is the initial pulse, and the second is the reflection from the air interface on the other side of the material. The distance between the two pips is read in terms of thickness of the ma-

terial. Any internal flaws in the material will show up as smaller pips between the initial pulse and the reflection. Flaws also will decrease the amplitude of the reflected pulse. Figure 5 shows typical measurements made on a material with and without flaws.

Ultrasonic thickness measurements also can be made by transmission methods. The principle is the same as in the reflection method, except that separate transmitting and receiving transducers are used, on opposite sides of the material. The same electrical circuits are employed. Measurements are made in terms of the time required for the pulse to travel through the material, and flaws are detected as a decrease in amplitude of the transmitted pulse. Transmission measurements are not commonly used for refinery inspections, since usually only one surface of the material under test is readily accessible. Transmission is often employed, however, for flaw detection, particularly when the flaws are such that sharp reflections are difficult to obtain.

A recently introduced transmission-reflection instrument has part of the circuits built into the transducer crystal housing instead of in the amplifier chassis. This permits the use of cables up to 40 feet long without requiring any compensating circuits. Thus, thickness measurements can be made on pipes and vessels in relatively inaccessible locations. Also, with this instrument it is possible to energize two transducers simultaneously. This feature permits simultaneous testing at two different frequencies. It also should be possible to compare an unknown thickness measurement directly with a standard, by displaying the two signals on the cathode ray tube simultaneously.

The resolution of reflection and transmission instruments of this type, using a 10 megacycle test frequency, is such that a 0.08 inch diameter hole 0.25 inch from the surface can be clearly resolved. The thickness of a specimen can be measured to $\pm$ 0.05 inch. It is possible to penetrate as much as 25 feet of steel and other

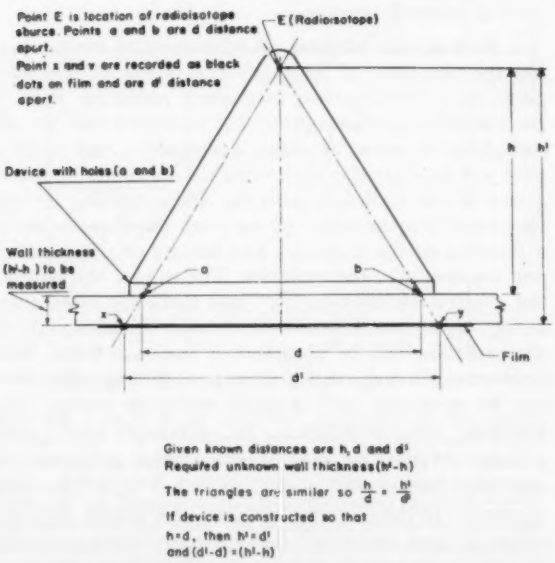

Point E is location of radioisotope source. Points a and b are d distance apart.
Point x and y are recorded as black dots on film and are d' distance apart.
E (Radioisotope)
Device with holes (a and b)
Wall thickness (h'-h) to be measured
a
b
x
y
h
h'
d
d'
Film
Given known distances are h, d and d'
Required unknown wall thickness (h'-h)
The triangles are similar so $\frac{h}{d} = \frac{h'}{d'}$
If device is constructed so that
h=d, then h'=d'
and (d'-d) =(h'-h)

FIGURE 6—Measuring thickness with gamma radiation is based on theory of similar triangles.

materials. Scattering of the ultrasonic radiation due to variations in grain size, grain orientation, surface condition, wave length, size of transducer and amplitude of the radiation all affect the depth of penetration and resolution that can be achieved.

The crystal transducer used to convert the electrical signal into a mechanical pulse in the material under test is effective only when the crystal and the metal make intimate contact. If the metal surface is rough or pitted, so that only a part of the crystal touches the surface, the resolution may be greatly reduced. Also, pits can be detected only by observing differences between a number of readings taken close together on the surface. Finally, the crystal transducer is sensitive to heat and mechanical shock. The instrument cannot be used on lines which are hotter than 250 F or subject to severe vibration.

2. Resonance Methods. A body will vibrate at a certain natural frequency when it is brought into contact with another body already vibrating at this frequency. This property of a body is called resonance, and the frequency of vibration is called the resonant frequency. The resonant frequency is a function of the dimensions and the elastic constants of the body. An example of this is the setting up of vibrations in a glass with a vibrating tuning fork. In some cases, several resonant frequencies or modes may exist. These usually are related harmonically.

The resonant properties of large objects such as pipes can be utilized for thickness measurements. Certain flaws such as laminations and bond discontinuities also can be detected by resonance methods if the flaws are perpendicular to the ultrasonic beam direction. The equipment consists of a variable frequency oscillator which supplies ultrasonic frequencies to a crystal transducer and synchronizes the sweep across the face of a cathode ray tube. Specimens of varying thickness in contact with the crystal load the crystal. The resulting resonant frequencies, which are determined by the thickness of the specimen, are read directly in terms of thickness as a function of their position on the cathode ray tube. Usually, the frequencies consist of a fundamental mode plus several harmonics. Using the fundamental mode alone, the practical thickness that can be measured is 0.4 inches. However, the useful range can be extended to 4 inches by using harmonic modes. This requires two readings of harmonic pips and a simple calculation. The lower limit of thickness which can be measured is 0.125 inches. The average accuracy of this type of instrument is about 2 percent.

The cost of resonant frequency instruments is lower than that of reflection instruments. Resonant frequency equipment is lighter and simpler to operate, particularly in the fundamental mode, and thicknesses can be read directly from interchangeable scales placed over the face of the cathode ray tube.

A special type of resonant frequency instrument used primarily for thickness measurements is a light, portable, battery-operated (but not explosion-proof) instrument operating in the audible frequency range. The signals are detected with headphones and a meter. Thicknesses from about 0.125 inches to 12 inches can be determined within about 3 percent. It is essential that the crystal transducer make good contact with

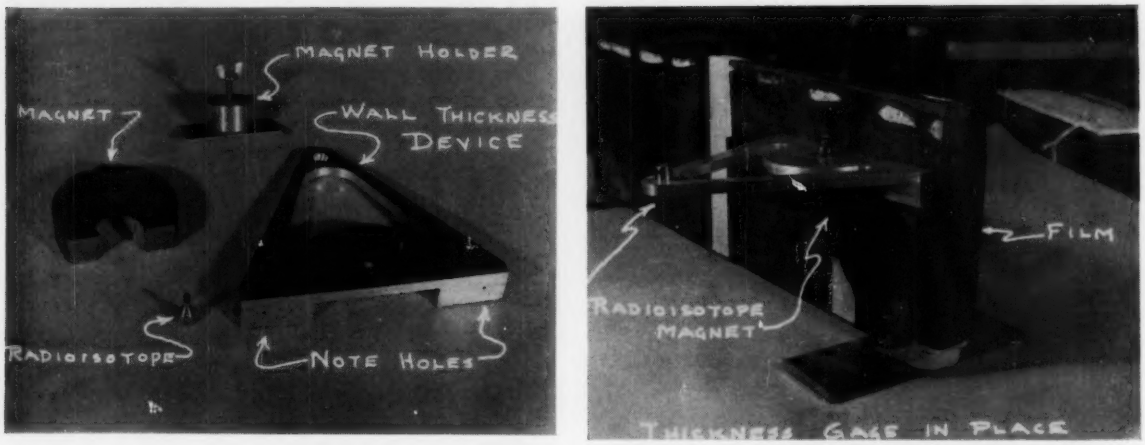


FIGURE 7—Gamma ray thickness gage works best on flat surfaces.

the part under test. Frequency indications are not clearly defined if the surface in contact with the transducer is corroded unevenly or heavily coked. Also, it has been found that the gage does not operate properly in cold weather because of temperature effects on the oscillator. Measurements can be made if the instrument is first warmed in a heated room and readings taken before the interior of the cabinet cools.

Radiation Methods for Thickness Measurements. X-ray and gamma ray techniques can be used to measure the thickness of materials and to detect defects. These radiation methods are of limited use in thickness measurements because of the low sensitivity and the required safety measures. It is also difficult to obtain satisfactory radiographs of too complicated shapes and thick specimens. The cost of making exposures is relatively high since X-ray film and processing are required. However, there are situations when no other method can be used. When a unit is onstream and operating at high temperature it may be desirable to inspect it without shutting down since a shutdown is expensive due to labor cost and production losses. Under such conditions it may be more economical to use the radiation film technique with the unit onstream.

Other detectors, such as Geiger or scintillation counters, can be used in place of film by scanning through the specimen with a radioisotope source and detector combination with the output plotted on a recorder. Such methods are at present under investigation. One incentive for the development of such non-film scanning systems is the possibility of applying them to onstream measurements at relatively high temperatures where films and ultrasonic transducers cannot be used.

The exposure time needed for radiation thickness measurements is a function of the penetrating power of the radiation and the sensitivity of the detector. This in turn depends on the thickness and absorption of a given material. Hence high energy sources must be used for thick specimens to allow reasonable exposure times. This means that for thick specimens, the cost of the source may become prohibitive and safety measures more involved.

1. The Similar Triangle Method. A method for using gamma radiation to measure thickness is based on the theory of similar triangles. The geometry of the setup and the method of arriving at the material thickness is shown in Figure 6. A radioactive source is located at E, at one apex of the triangle. The radiation is collimated and reaches the surface of the piece to be measured through holes a and b. A film is placed on the other side of the piece, and records two black dots at x and y, where the radiation passes through the wall. From the known distances d, d^1, and h, a simple calculation will give the unknown wall thickness h^1-h, as shown in Figure 6.

The device and the film holder are held in place by magnets, as shown in Figure 7. The method works best on flat surfaces, but corrections can be made for curved surfaces. The thickness that can be measured is limited by the penetrating power of the source radiation. Accuracy is about 5 percent.

2. Back-scatter Method. Another method for measuring the thickness of materials makes use of the phenomenon of back-scatter of gamma radiation. Part of the radiation from a source will penetrate and be absorbed by the material under investigation, and another part will be scattered-back from the specimen by interaction of the radiation with the atoms making up the specimen. The quantity of back-scattered radiation is a function of the thickness and density of the material and the energy of the radiation. The thicker the sample, the greater the back-scatter since there are more scattering atoms available. At a certain thickness, all of the radiation will be absorbed or back-scattered. This represents the maximum thickness of that material that can be measured with a given radiation energy. For example, using a milligram of radium as source and a Geiger-Mueller detector, it is possible to measure iron and steel thicknesses up to 0.75 inches with 5 percent accuracy. If the distance between the source and detector is kept constant, then for any given material the detector can be calibrated to read thickness directly.

TO BE CONTINUED

Here's Packaged Boiler Cost

From these data you can quickly estimate purchased costs, erection costs and equipment weight for packaged steam generators

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ANY ITEM of equipment completely designed, fabricated or erected as a unit can be defined as "packaged" equipment. A prime objective in selecting this type of equipment is to provide a commercial plant, erected at a minimum capital investment, that is capable of reliable operation for the life of the plant at low operating and maintenance costs.

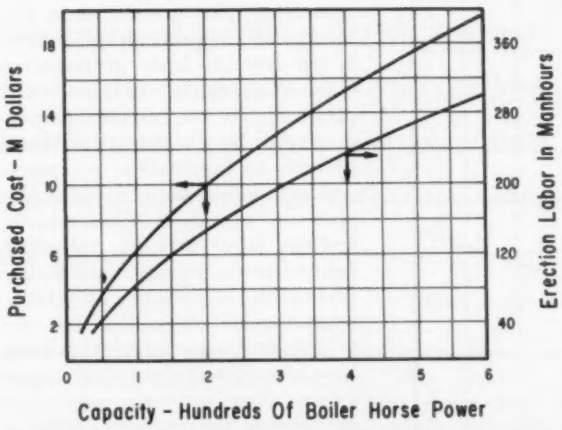

FIGURE 1—Use these costs for packaged firetube steam generators at 100 psig operating pressure. Horizontal multiple-pass design includes: Burner (gas/oil), Blower (forced draft), Boiler feed control, Water column, Boiler fittings, Relief valves, Insulation and Jacket, Control panel, Program automatic stop and start, Oil pump and Heater set. Erection labor includes: Unload, rig, haul and erect. For operating pressure other than 100 psig use these factors: 50 psig multiply costs by 0.97, 150 psig multiply costs by 1.03, 200-250 psig multiply costs by 1.04.

Recognizing the opportunity for savings in plant investment costs, the boiler industry has standardized construction in many boiler sizes which, if selected, offer substantial savings in purchased cost. The smaller standardized boiler are completely shop assembled units equipped with fuel burning equipment, mechanical draft equipment, automatic control and accessories shipped as a "package" ready for installation.

This article presents the necessary cost data for these package boiler plants required in preparing plant investment and manufacturing cost estimates. Similar cost data covering large field erected boiler plants have been presented in an earlier publication.[1]

Packaged boiler units are automatically controlled and will operate efficiently at both low and high capacities. They can be installed out of doors and at remote locations and are well suited for operations where the steam demand varies widely. The package boiler concept can be provided in either firetube or watertube designs.

Firetube units are built for capacities from 500 to about 20,000 pounds per hour steam (600 boiler hp) at pressures of 10 to 600 psig. However, most firetube units operate at or below 250 psig. The boiler consists of a water filled cylindrical shell housing and an internally fired furnace where the combustion gases are contained inside the tubes. The maximum diameter boiler shell available in firetube designs is about 8 feet which determines the practical limits of both capacity and pressure.

Packaged firetube units are designed for either two, three or four pass operation utilizing oil, gas or a com-

bination of these fuels. They operate with a fuel/steam efficiency of approximately 80 percent. These units are rated in terms of maximum continuous boiler hp delivered where a boiler hp is defined as being equivalent to the evaporation of 34.5 lbs. of water per hour from a temperature of 212° F into dry saturated steam at the same temperature and is equivalent to a heat release of 33,475 BTU/hour.

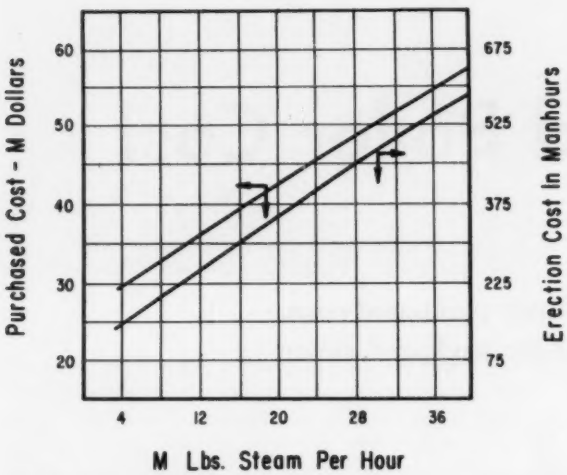

FIGURE 2—Use these costs for packaged watertube steam generators at 250 psig operating pressure. These costs include: Freight, supervision, combination oil and gas burners, duplex oil heater and pump, stub stack, feed water regulator and valve, forced draft fan and driver, combustion control and panel, flame failure safeguard and soot blower. Labor includes: Unload, rig, haul and erect. For operating pressures other than 250 psig use these factors: 500 psig multiply costs by 1.03, 750 psig multiply costs by 1.06, 900 psig multiply costs by 1.10.

Watertube units pick up in capacity near the upper end of the firetube range and extend the "packaged" design concept up to approximately 60,000 pounds per hour of steam generating capacity at pressures up to 900 psig. The larger size units are generally shipped as shop assembled units with the firing and draft equipment shipped separately. Watertube units are also designed primarily for oil, gas or combination firing, however, some packaged units equipped with specially designed stokers are operated successfully on solid fuels.

The pressure and size limitation imposed on the firetube units do not exist for the watertube design since the drum diameter is not the limiting factor and capacities can readily be increased by adding additional tubes. The chief limitation imposed on the capacity of watertube units is one of shipping clearances and over-all dimensions are sized to fit standard railroad flat cars. An excellent report has been prepared by Bellas[2] which discusses the basic design and characteristics of packaged boilers and should be referred to when specific details are desired.

The Control System for packaged boiler systems generally include ignition proving, combustion control, flame-failure equipment, safety shut-off switches, limit switches, plus start-up and programming. It constitutes a combination of combustion controls and operation safeguards and is commonly referred to as the boiler's program control system. Its basic function is to take over the operator's role during initial operation from a cold start position, normal operation throughout load demand range and handling shutdowns.

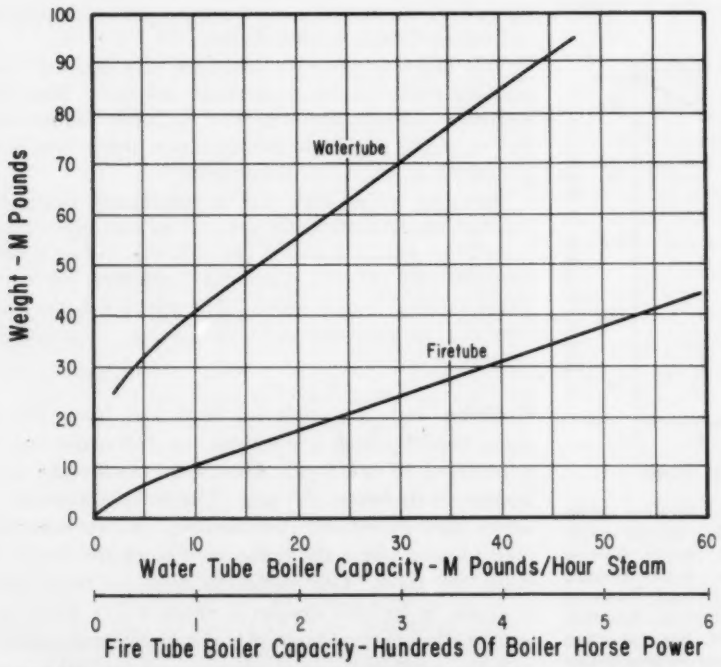

FIGURE 3—Pick off approximate weights of packaged boiler plants from this chart.

COSTS AND ERECTION

The purchased cost of both firetube and watertube packaged steam generating units are shown in Figures 1 and 2 respectively. Also shown is the erection labor in manhours required to install these units. These plants require no prepared foundation other than a floor of sufficient strength to support the equipment and no skilled labor for assembly prior to operation. Consequently, erection labor includes unloading, hauling to site, rigging and erecting. Equivalent equipment operating hours required in hauling the units to the site and rigging operations have been included at a rate equivalent to three manhours per equipment hour. Approximate weights of both firetube and watertube units versus capacity rating are shown in Figure 3 for use in estimating foundation requirements and shipping charges.

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[1] Prater, N. H. and Antonacci, D. W. Petroleum Refiner, Vol. 38, No. 5, May 1959, p. 243-246.

[2] Bellas, R. C., *Power*, August 1958, p. 79-100.

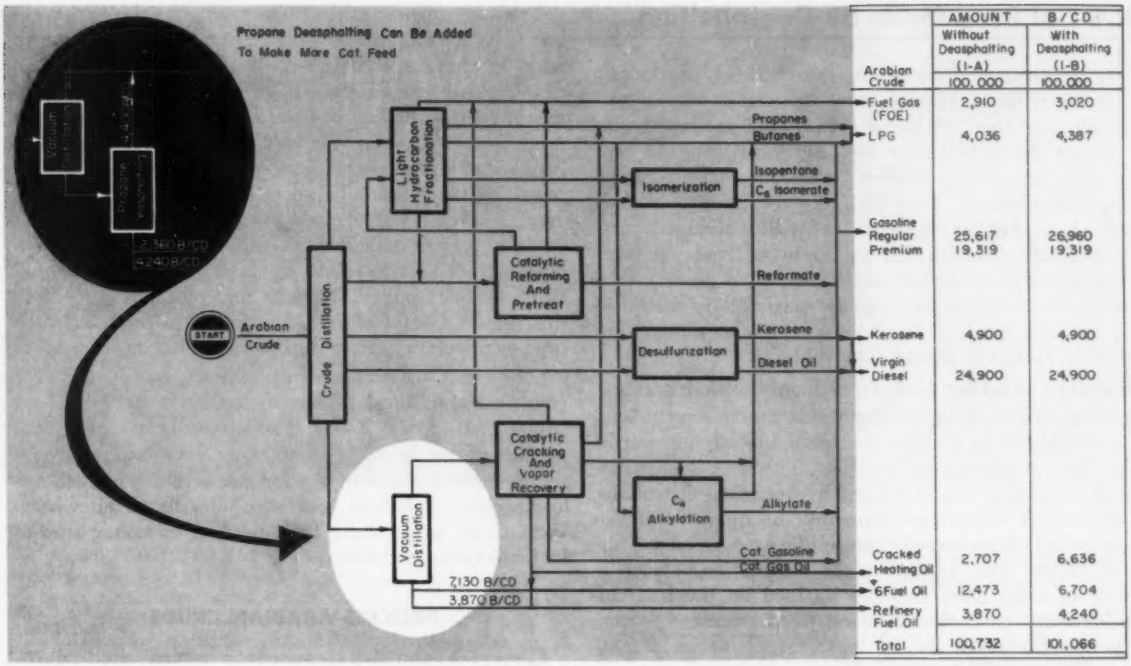

FIGURE 1—Adding a propane deasphalting unit to the refinery process scheme will reduce the No. 6 fuel oil production to slightly over half of its previous rate.

Now Cat Feed Made by Deasphalting

The propane deasphalting process now uses improved technique so that it is more suitable for preparing catalytic cracking feed from residues. These pilot plant data show the economic incentive for using the process

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Foster Wheeler Corporation, New York City

PROPANE DEASPHALTING, using improved techniques, makes possible the recovery of large quantities of excellent quality virgin catalytic cracking feed from heavy vacuum residues. This in turn can reduce No. 6 fuel oil production, particularly in the case of boiling of low asphalt content and high content of oil boiling above 1,000° F. The deasphalted oil recovered may be added to existing catalytic cracking feed to increase gasoline production, or may be used to displace lighter fractions from catalytic cracking feed to enhance virgin middle distillate production.

The theory of propane deasphalting is reviewed briefly in the accompanying box. The process has been employed for many years in the refining industry to separate heavy lubricating oil feed stocks from vacuum residues. However, improved contacting equipment and processing techniques makes the process suitable for producing clean heavy distillates from vacuum residues and for reducing the production of bunker fuel oil. This article will discuss pilot plant studies showing the improvement in yield and quality of product which can be obtained from propane deasphalting.

APPLY LIGHT HYDROCARBON DEASPHALTING

Although light hydrocarbon deasphalting is applicable to the residue from any crude in any refinery situation where it is desired to cut catalytic cracking feed or other material from the portion of the crude boiling above 1,000° F., some specific cases should be noted, by way of illustration, where the use of light hydrocarbon deasphalting is particularly advantageous:

- **Highly paraffinic crudes having a large amount of material boiling above 1,000° F. but a low asphalt content.** The use of light hydrocarbon deasphalting is most advantageous here because the highest percentage increase in catalytic cracking feed and high-

est percentage decrease in bunker fuel production can be realized. Highly paraffinic crudes are notoriously poor base stocks for commercial asphalt manufacture. An important reason for this is that the high boiling wax in the residue lowers the ductility of the asphalt. Heavy lube extract-precipitated asphalt blends generally are better in quality than the corresponding straight reduced asphalts from the same crude, but in the case of paraffinic crudes the improvement in quality of the asphalt, particularly ductility, is greatest because the nearly complete elimination of wax from the asphalt is possible.

- **Catalytic cracking feeds from highly asphaltic crude sources where deasphalting yields are relatively low.** It should not be inferred that deasphalting necessarily is disadvantageous in this case. The size, investment and operating cost of a light hydrocarbon deasphalting unit is determined more by the quantity of deasphalted oil recovered than by the amount of residue fed to the unit. Therefore the installation of such a unit in some cases may be justified on the basis of additional catalytic cracking feed recovery, even though the reduction in bunker fuel oil yield may not be spectacular.
- **Maximum virgin middle distillate yield while maintaining a fairly high level of gasoline production.** Propane deasphalting will prove extremely valuable in these special situations which have not been encountered too often in the past, but which will become increasingly important in the future. It is assumed that the crude is moderately heavy and does not have a high yield of virgin naphtha. The catalytic cracking feed requirements then would exceed the available heavy vacuum distillate after taking a maximum yield of virgin middle distillate for sale as high grade diesel fuel, turbine fuel, etc. In this case light hydrocarbon deasphalting offers a means of shifting the catalytic cracking feed lower in the crude by making up catalytic feed requirements out of vacuum residue. When this is done the requirements for virgin middle distillate fuel and catalytic cracking feed no longer compete.
- **Middle distillate yields augmented by the production of deasphalted oils.** Considerable interest may be given this situation in the future, particularly abroad. Such production should find ready application in large diesel and gas turbine installations which require a very clean distillate fuel, but are equipped to handle a rather viscous material of high pour point. This application has been practiced successfully commercially, although not on a large scale.

SEE EFFECT ON REFINERY ECONOMICS

To illustrate the effect of the use of the light hydrocarbon deasphalting process on refinery economics, typical refinery operations have been set up, with and without deasphalting, on two different crudes which are of wide interest at the present time. Case I-A (without deasphalting) and Case I-B (with deasphalting) represent a typical refining operation on Arabian crude. This crude has been shown because of its wide interest and because of the availability of all necessary process data to set up the refining balance. It should be noted, however, that the general yield structure is similar to that of a typical midcontinent crude so that conclusions drawn from a comparison of Cases I-A and I-B would be applicable qualitatively to a midcontinent crude. For this reason Gulf Coast-Midcontinent prices have been used in economic studies in these cases.

Case II-A (without deasphalting) and Case II-B (with deasphalting) represent refining operations on Minas (Sumatran) crude. These operations are typical of the possibilities of light hydrocarbon deasphalting on similar crudes found in the far east and of some similar low asphalt high wax content crudes found elsewhere. West Coast prices have been used in economic studies in these latter two cases.

TABLE 1—Deasphalter Utilities for Processing Arabian Crude (Case I-B)

UTILITIES	Amount
50 psig Steam, lb./hr.	38,600
85° F. Cooling Water, GPM	8,600
Heat Load, MM Btu./Hr.	72
Electrical Load, KW	730

PROCESS ARABIAN CRUDE

Cases I-A and I-B represent a typical modern refinery which processes 100,000 bpcd of Arabian or similar, crude. Processing units include two-stage crude distillation, catalytic cracking, catalytic reforming, pentane-hexane isomerization, alkylation, kerosine and diesel fuel hydrodesulfurization, gas recovery, etc. All process units are identical in the two cases; the only difference is that a propane deasphalting unit, omitted in Case I-A, is included in Case I-B.

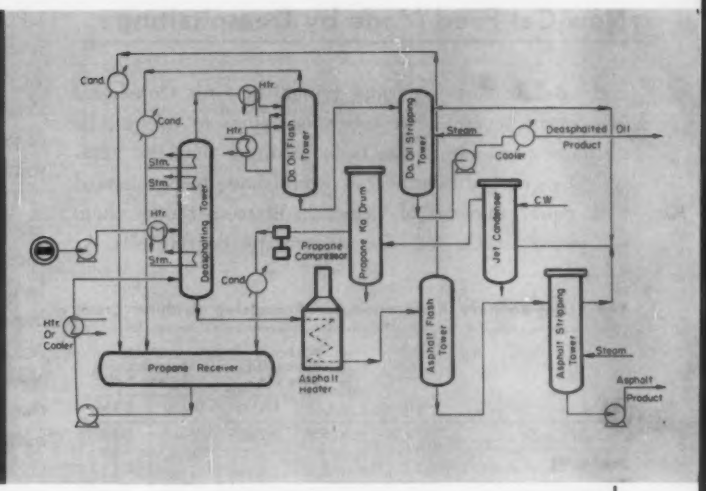
A simplified schematic refinery flow diagram of Case I is given in Figure 1. Table 1 gives the utility requirements of the deasphalting unit in Case I-B.

It has been assumed that the refinery would produce virtually a maximum yield of kerosine plus virgin diesel fuel, and that a maximum yield of vacuum distillate after diesel fuel (plus deasphalted oil in Case I-B) would be catalytically cracked. The final cut point of the virgin diesel fuel was determined by pour point limitations and the final cut points of the vacuum distillate and deasphalted oil were determined on the basis of metal content. Further, it has been assumed that two grades of gasoline would be produced, a premium grade of 100 octane number, F-1 and a regular grade of 93 octane number, F-1. In Case I-A the refinery fuel consists of refinery gas and vacuum residue, and in Case I-B the refinery fuel is refinery gas and precipitated asphalt.

The product yields for the two cases are summarized in Figure 1. It will be noted that by including a deasphalting unit in Case I-B and processing the deasphalted oil in the catalytic cracking unit (compensating for the increased feed rate by lower conversion) it is possible to reduce the No. 6 fuel oil production to slightly over half that in Case I-A. This reduction in No. 6 fuel oil is accompanied by a slight increase in the gasoline production and a marked increase in distillate fuel oil production.

Table 2 presents the respective product realizations for Cases I-A and I-B. The values assigned to crude

HOW PROPANE DEASPHALTING WORKS



THE LIGHT PARAFFIN hydrocarbons such as propane and butane exhibit a selective solvent action for heavy petroleum fractions. Selection is primarily on the basis of molecular weight but there is some preferential solubility for paraffinic over aromatic hydrocarbons in any given molecular weight range. The variation of solubility with temperature is inverse, i.e., immediately below the critical temperature only the lowest molecular weight fractions of a crude residue are soluble, but as the temperature is decreased, progressively higher molecular weight fractions are dissolved.

Propane deasphalting is used universally in lubricating oil refining to prepare bright stock and cylinder oil feed stocks from crude residues which contain asphalt. To a lesser extent propane and butane deasphalting are used to recover additional catalytic cracking feed fractions, too high in boiling point for commercial distillation.

In commercial application of the light hydrocarbon deasphalting process, the solvent is contacted with the crude residue in a continuous counter-current system similar to those used in other solvent extraction processes, except that provision must be made for operation at pressure ranging from 400 to 700 psig. In the early days these systems generally were made up of mixers and settlers, often not arranged in true counter-current fashion. In recent years, however, all plants have been constructed with counter-current towers containing either baffles or perforated plates.

A schematic flow diagram of a typical deasphalting unit is shown in the accompanying figure. The bulk of the solvent, with the deasphalted oil in solution, comes from the top of the contacting tower and passes to the recovery system. Steam heat, or a combination of steam heat and fired heaters, is used to evaporate the solvent. A final steam stripping removes last traces of solvent from the deasphalted oil. The asphalt, together with some solvent passes from the bottom of the contacting tower to the asphalt stripping system. This system consists of a fired coil heater and a flash tower, followed by a steam stripper to remove the last traces of solvent from the asphalt. Some early units used steam heating in place of a fired coil but in these cases it was necessary to add a light oil to cut the viscosity of the asphalt in the recovery system.

More advanced contacting systems such as the rotating disc contactors were used in the pilot plant studies of the Foster Wheeler Research Laboratory at Carteret, New Jersey. These extensive studies on vacuum residues from a wide variety of crudes demonstrated the improvement of product which can be achieved with propane deasphalting using improved techniques. The accompanying article gives data which may be used to compare the deasphalting process with other processing schemes.

Modern vacuum pipe stills, for example, are capable of distilling petroleum fractions boiling as high as 1000 to 1100° F., or roughly 600 mol. wt. Unless the metal content of the feed is very low, however, attempts to distill materials boiling over 1000° F., more or less, depending on the crude in question, results in metal contamination of the distillates, which makes such distillates unattractive for catalytic cracking feed because of catalyst poisoning. Entrainment of asphaltic residual material also becomes a problem in the production of heavy distillates for catalytic cracking feed because asphaltic material causes excessive coking of the catalyst. For these reasons much high molecular weight material potentially usable as catalytic cracking feed is lost in vacuum residue which is the primary component of unprofitable bunker fuel oil.

Visbreaking and coking also have been employed extensively by refiners to reduce the yield of high-boiling residues. Neither process, however, is completely satisfactory. Visbreaking produces a small yield of unstable, relatively low octane gasoline and no catalytic cracking feed stock. The potential reduction in bunker fuel is small, and visbreaking cannot be applied to the residues from all crudes as many of them cause very rapid coking of the fired heater tubes. Coking generally can be applied to the residues from the commonly used crudes and does eliminate all viscous residual material. On the debit side, however, coking produces unstable, poor octane gasoline, compared with those produced by modern refining processes, an unstable gas oil, and a solid residue. The coker gas oil is not necessarily of the best quality for catalytic cracking feed. If the coke is not low enough in sulfur content to meet electrode coke specifications it may be difficult to dispose of profitably.

Propane deasphalting, on the other hand, offers a means of separating virgin catalytic cracking feed of good quality from vacuum residues, with yields comparable with those obtainable by coking. The sharpness of separation in many existing deasphalting units making catalytic cracking feed, however, has been disappointing. Modern deasphalting techniques, including the use of the rotating disc contactor, make it possible to produce better yields of much better quality deasphalted catalytic cracking feed stocks than have been obtained in earlier deasphalting installations. For example now it is possible to produce deasphalted oils having nickel plus vanadium contents of one part per million or less. The asphalt produced, although high in melting point (175 to 275° F.), is fluid at high temperatures and thus does not present the handling problem of coke.

and products are generally typical of Gulf Coast and Midcontinent areas. In assigning values to the middle distillate products it has been assumed that the catalytically cracked heating oils would have to be blended with equal amounts of virgin distillate to render them sufficiently stable for sale as domestic heating oils. As LPG prices vary widely with season and location only a nominal value of five cents per gallon has been assumed. In the case of the fuel oil a nominal value also has been assumed because of local variations. The assumed value of $1.85 may be regarded as a maximum because in some areas lower prices prevail.

The advantage for installing the propane deasphalting unit is considered by generalizing and simplifying the economics. The added investment for Case I-B over I-A has been accounted for as the cost of the deasphalting unit plus the utilities required for its operation. Added operation costs are propane deasphalting plant operator salaries and maintenance. It is assumed that the slightly increased utility installation would not require additional operators. Added fuel requirements are accounted for by deduction from refinery products. This economic advantage, therefore, may be summarized as shown in Table 3.

TABLE 2—Refinery Realization for Processing Arabian Crude

ITEM	$/Bbl.	Without Deasphalting (Case I-A) B/CD	Without Deasphalting (Case I-A) $/Day	With Deasphalting (Case I-B) B/CD	With Deasphalting (Case I-B) $/Day
Arabian Crude	2.77	100,000	277,000	100,000	277,000
Products:					
LPG	2.10	4,036	8,476	4,387	9,213
Premium Gasoline	5.25	19,319	101,425	19,319	101,425
Regular Gasoline	4.62	25,617	118,351	26,960	124,555
Kerosine	3.99	4,900	19,551	4,900	19,551
Virgin Diesel	3.78	22,193	83,890	18,264	69,038
Domestic Oil	3.46	5,414	18,732	13,272	45,921
No. 6 Fuel Oil	1.85	12,473	23,075	6,704	12,402
Total	....	93,952	373,500	93,806	382,105
Operating Margin	....	.....	96,500	.....	105,105

Realization of Case I-B over Case I-A $8,605/Day.

TABLE 3—Arabian Crude—Advantage of Case I-B Over Case I-A

Case I-B Minus Case I-A	Dollars
Added Investment:	
Propane Deasphalting (11,000 BPCD)	3,200,000
Utilities	300,000
Total Added Investment	3,500,000
Annual Realization:	
Product Realization	3,150,000
Less Operator Salaries	— 78,840
Less Maintenance	— 112,000
Total Annual Realization	2,959,160
Payout (Before Taxes and Depreciation)	1.18 Yrs.

TABLE 4—Deasphalter Utilities for Processing Minas Crude (Case II-B)

UTILITIES	Amount
50 psig Steam, Lb./Hr.	64,400
85° F. Cooling Water, GPM	14,400
Heat Load, MM Btu./Hr.	120
Electrical Load, KW	1,220

PROCESS MINAS CRUDE

Cases II-A and II-B represent a typical modern refinery which processes Minas, or similar crude. Processing units include two-stage crude distillation, catalytic

TABLE 5—Refinery Product and Fuel Balance Processing Minas Crude

ITEM	AMOUNT, BPCD Without Deasphalting (Case II-A)	AMOUNT, BPCD With Deasphalting (Case II-B)
Crude Charge	100,000	77,131
Products to Sales:		
LPG	6,352	6,617
Premium Gasoline	16,468	16,471
Regular Gasoline	25,490	25,552
Kerosine	4,900	4,900
Virgin Diesel Fuel	13,100	8,984
Cracked Heating Oil	7,064	9,238
No. 6 Fuel Oil	23,370[1]	3,003[2]
Total	96,744	74,765
Refinery Fuel:		
Gas (F.O.E.)	2,850	2,860
Residue	2,650	2,240
Total Refinery Fuel (F.O.E.)	5,500	5,100

[1] 110 F. Pour Point.
[2] Less than 50 F. Pour Point.

TABLE 6—Refinery Realization for Processing Minas Crude

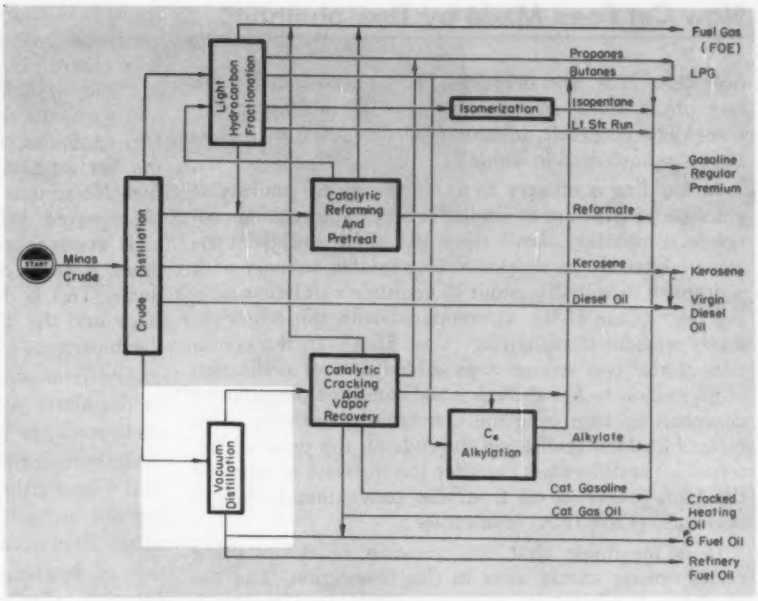
ITEM	$/Bbl.	Without Deasphalting (Case II-A) B/CD	Without Deasphalting (Case II-A) $/Day		With Deasphalting (Case II-B) B/CD	With Deasphalting (Case II-B) $/Day	
Minas Crude	3.52	100,000	352,000		77,131	271,501	
Products:							
LPG	2.10	6,352	13,339		6,617	13,896	
Premium Gasoline	6.30	16,468	103,748		16,471	103,767	
Regular Gasoline	5.35	25,490	136,372		25,552	136,703	
Kerosine	4.41	4,900	21,609		4,900	21,609	
Virgin Diesel	4.20	6,036	25,351		.....	.....	
Domestic Oil	2.80	14,128	39,558		18,222	51,022	
No. 6 Fuel Oil	{2.15 / 1.20}	23,370[1]	{50,246 / .....}	28,044	3,003[2]	{6,456 / .....}	3,604
Total	..	96,744	390,223	368,021	74,765	333,453	330,601
Operating Margin	....	.....	38,223	16,021	.....	61,952	59,100

Realization of Case II-B over Case II-A:
No. 6 Fuel Oil @ $2.15/Bbl. $23,729/Day.
No. 6 Fuel Oil @ $1.20/Bbl. $43,078/Day.
[1] 110 F Pour Point.
[2] Less than 50 F. Pour Point.

cracking, catalytic reforming, pentane isomerization, alkylation, gas recovery, etc. Case II-B also includes a propane deasphalting unit.

In Case II-A the feed to the refinery is 100,000 bpcd (as in Cases I-A and I-B). In Case II-B, however, the introduction of propane deasphalting for the preparation of additional catalytic cracking feed causes a large increase in gasoline yield, rather than middle distillate yield (as in Case I-B vs. I-A). It appeared more realistic, therefore, to base Case II-B on the same number of barrels of gasoline product as in Case II-A, rather than on the same crude throughput. Consequently, in Case II-B, the refinery feeds only 77,131 bpcd of Minas crude.

The catalytic cracking unit and vapor recovery facilities are enlarged to maintain gasoline production by cracking deasphalted oil. The alkylation facilities are identical in the two cases. The crude distillation, virgin light-ends fractionation, catalytic reforming, and pentane isomerization facilities in Case II-B are reduced in proportion to the reduction in crude throughput, as compared with Case II-A.



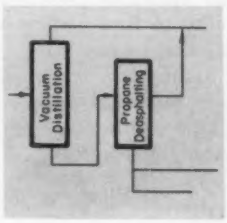


FIGURE 2—When processing Minas crude it is assumed the gasoline production will be held constant while adding a propane deasphalting unit. Thus less crude throughput is needed.

A simplified schematic refinery flow diagram of Case II is shown in Figure 2. Table 4 gives the utility requirements of the deasphalting unit in Case II-B.

A maximum yield of kerosine plus virgin diesel fuel was assumed to be produced by the refinery. Also a maximum yield of vacuum distillate after diesel fuel (plus deasphalted oil in Case II-B) would be catalytically cracked. The final cut point of the virgin diesel fuel was set by maximum pour point, and the final cut points of the vacuum distillate and deasphalted oil were determined by metal content.

Further, it has been assumed that two grades of gasoline would be produced, a premium grade of 100 octane number, F-1, and a regular grade of 93 octane number, F-1. In Case II-A the refinery fuel consists of refinery gas and vacuum residue, and in Case II-B the refinery fuel is refinery gas and precipitated asphalt.

The product yields for the two cases are summarized in Table 5. The introduction of a deasphalting unit in Case II-B increases the potential catalytic cracking feed, after diesel, from a given amount of crude by about 44 percent. For this reason, as noted above, the gasoline production in Case II-B has been held about the same as in Case II-A and the crude feed to the refinery has been reduced to 77,131 bpcd. The production of residual fuel has been reduced from 23,370 bpcd in Case II-A to 3,003 bpcd in Case II-B.

Table 6 presents the respective product realizations for Cases II-A and II-B. The values assigned to crude and products are generally typical of the West Coast, as the use of Minas (Sumatran) crude is logical in this area. In assigning values to the middle distillate products it has been assumed that all light catalytic cycle stock sold as distillate fuel oil would have to be blended with an approximately equal quantity of virgin middle distillate for stability. A nominal value of 5 cents per gallon has been assumed for LPG.

Because of the profound effect of the price of No. 6 fuel oil on the economics of the two cases two separate comparisons have been made, one on the basis of a "normal" price of $2.15 per barrel for No. 6 fuel oil, and the other on the basis of a "distress" fuel oil price of $1.20 per barrel.

It will be noted that Case II-A (without deasphalting) with its 23,370 bpcd production of 110° F., pour point No. 6 fuel oil, is not a profitable operation, as the refinery operating margin is below forty cents per barrel even at the higher fuel-oil price, and granting that such high pour fuel oil is saleable.

In considering the economic advantage of Case II-B over Case II-A much the same procedure has been followed as in Cases I-A and I-B. The Case II-A and Case II-B comparison is somewhat more complicated, however, because of the difference in refinery capacity in the two cases. Case II-B has been credited with the cost of the incremental refinery capacity of Case II-A

over Case II-B, and debited with the deasphalting unit investment, and incremental catalytic cracking investment. The economic advantage of Case II-B over Case II-A is summarized in Table 7.

In building a refinery to produce a given quantity of gasoline from Minas or similar crude, the foregoing economic comparison shows there is a slight initial investment advantage in constructing a smaller refinery with a propane deasphalting unit to maintain catalytic cracking feed (Case II-B), as compared with the larger refinery without deasphalting (Case II-A). In the operation of the two refineries an added annual realization of $8 million to $15 million is indicated for the propane deasphalting case over the conventional refinery. This range of added realization depends on the price of No. 6 fuel oil and does not consider the question of whether the high-pour fuel oil from the conventional refinery operation (Case II-A) is saleable.

It is inevitable that the question of deasphalting versus coking should arise in this connection. The use of delayed coking on such paraffinic feed stocks is highly questionable because of the probability of furnace tube coking, and therefore may be excluded from consideration here. The use of fluid coking as an alternate to propane deasphalting would appear to be feasible. Unfortunately, adequate data on this type of operation are not available to set up a valid comparison.

DISPOSE OF ASPHALT THIS WAY

Where heavy lube extracts are available commercial asphalts can be produced by fluxing the precipitated asphalt with the lube extracts in various combinations. By choice of blending components, and component proportions, considerable control over the characteristics of the asphalt products is possible. Needless to say this can offer an attractive outlet for the asphalt.

A second possible use for the asphalt is as refinery fuel. The more complete and thorough-going the recovery and utilization of light ends the greater is the need for the refinery to supplement its refinery fuel gas with fuel oil for refinery heat requirements. By distributing the uncut asphalt in a hot circulating loop line it would be possible to burn the asphalt in the large steady fuel users such as the refinery boiler house, the crude distillation units, and in the deasphalting unit itself. It is assumed that in the process units some burners would be on gas and some on asphalt to facilitate unit control and to balance off the heat load between gas and asphalt. Where a large public utility power house adjoins the refinery, as in some refineries in the United States, it would be most attractive to extend the hot asphalt loop to supply the public utility with fuel. No serious problems in burning the asphalt would be expected. When the uncut asphalt is atomized at a high enough temperature in the burner a short, hot flame is produced, quite unlike the usual bunker fuel flame. This is due to the absence of low boiling cutter stock and the high temperature of the asphalt entering the burner.

Any remaining asphalt which cannot be disposed of in the above ways must be blended off with catalytic cycle stock, or any other available distillate fuel oil, to make bunker fuel oil. It is readily appreciated, however, that where either or both of the above means of utilizing the asphalt, without recourse to cutting with distillate stocks, can be employed, a considerable reduction of bunker fuel production can be achieved, and complete elimination of bunker fuel is a possibility where the asphalt content of the refinery crude feed is low.

(Original presentation was before the American Institute of Chemical Engineers, San Francisco, December 6-9, 1959.)

TABLE 7—Minas Crude—Advantage of Case II-B Over Case II-A

Case II-B Minus Case II-A	Dollars	
Capital Savings		
Savings From Reduced Capacity	9,450,000	
Less Added Investment Costs		
Catalytic Cracking Cap Inc.	—3,000,000	
Propane Deasphalting (18,357 BPCD)	—4,500,000	
Utilities	0	
Total Capital Savings	1,950,000	
No. 6 Fuel Oil Price Basis	$2.15/Bbl.	$1.20/Bbl.
Annual Realization:		
Product Realization	8,650,000	15,700,000
Less Operator Salaries	—78,840	—78,840
Less Maintenance	0	0
Total Annual Realization	8,571,160	15,621,160

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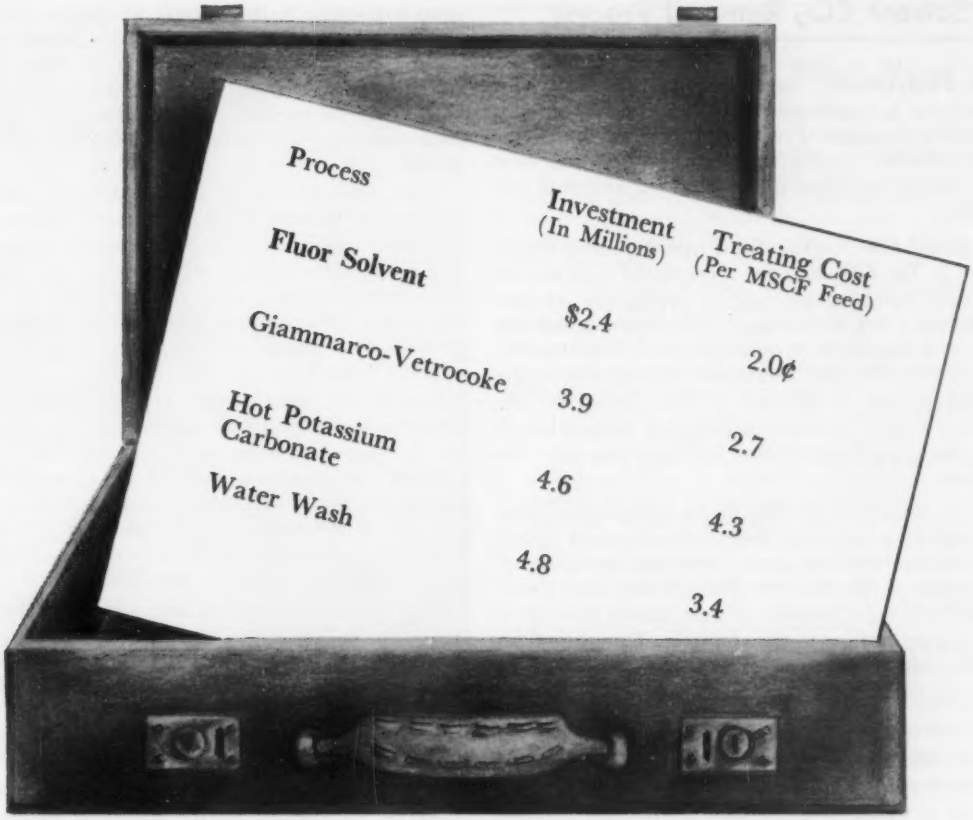


Fluor Solvent CO_2 Removal Process

When CO_2 content is high and product specifications are relaxed, this new process is the least costly of several alternate processes

A. L. Kohl and P. A. Buckingham
The Fluor Corporation, Ltd., Los Angeles

THE FLUOR SOLVENT CO_2 Removal Process represents a new approach to the problem of purifying high-pressure gas streams rich in CO_2. The process is exceedingly simple and the economics are quite favorable compared with other available processes.

When research was started on this process, the principal available techniques for CO_2 removal were the water wash and monoethanolamine processes.

The principal drawback of the water wash process is its very high energy requirement for pumping, which results from the relatively low solubility of CO_2 in water. The ethanolamine process, on the other hand, suffers from an excessive heat energy requirement for stripping when large quantities of carbon dioxide are handled, as a result of the high heat of reaction between carbon dioxide and monoethanolamine. The research program, therefore, was aimed at developing a process which combined the low heat energy requirement of the water wash process with the low pumping requirement of the amine process. Here's the commercial form of the process plus economic data to evaluate it.

Fluor Solvent CO_2 Removal Process . . .

Process Description. Commercial designs have been developed for a number of applications of the Fluor Solvent CO_2 Removal Process. These designs employ different solvents, operating temperatures and flow schemes, depending upon the specific requirements and conditions.

A simplified flow diagram for a typical plant is shown in Figure 1. The CO_2-rich gas is contacted with solvent in a conventional countercurrent absorption column. Lean solution is fed to the top of this column at ambient or slightly subambient temperature and it leaves the bottom rich in CO_2 and somewhat warmer, due to the heat of absorption. In addition to CO_2, the solvent absorbs water vapor, hydrogen sulfide and mercaptans, if present, and a small quantity of hydrocarbons from the gas stream.

The rich solution is flashed to an intermediate pressure to release a major portion of the dissolved hydrocarbons and the resulting gas is compressed and recycled to the bottom of the absorber. The solvent which is still at a relatively high pressure is next passed through a power recovery turbine to the atmospheric pressure flash vessel from which the desorbed CO_2 is vented.

Water, hydrogen sulfide, and mercaptans are stripped from the solvent by the large volume of carbon dioxide, so that an appreciable net removal of these components is also accomplished by the process. The solution cools during the stripping steps because of the heat released by CO_2 desorption and expansion. Cool lean solution is recycled to the top of the absorber.

In the flow scheme shown, regeneration is effected by atmospheric pressure flashing, so that the lean solution leaves the regeneration step in approximate equilibrium with carbon dioxide gas at one atmosphere pressure. Since the lean solution returned to the absorber contains carbon dioxide equivalent to one atmosphere partial pressure, it obviously cannot reduce the carbon dioxide content of the treated gas below this level. At 800 psig, for example, this means a minimum carbon dioxide content in the treated gas of about 2 percent with the flow diagram shown. If a lower level of carbon dioxide is required, air or other inert gas may be used for stripping, or vacuum flashing may be employed.

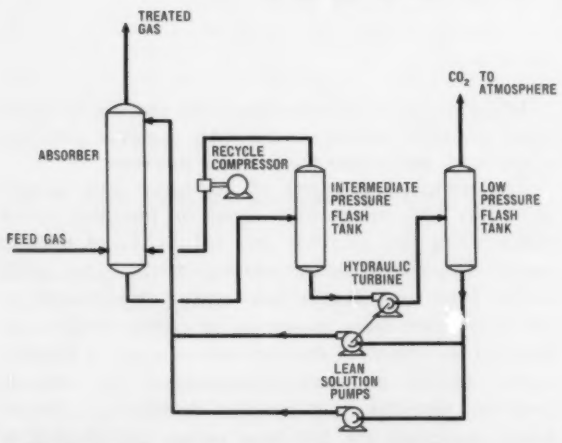


FIGURE 1—Flow scheme for this process shows conventional countercurrent absorption followed by atmospheric pressure flashing for regeneration. Other regeneration schemes are sometimes necessary.

Since only the carbon dioxide left in solution after atmospheric flashing must be removed under vacuum, the power requirement for this operation is nominal and can be further reduced by removing CO_2 in two or more subatmospheric stages. Air stripping requires even less power than vacuum flashing but suffers from the possible disadvantage of introducing a trace of oxygen into the treated gas.

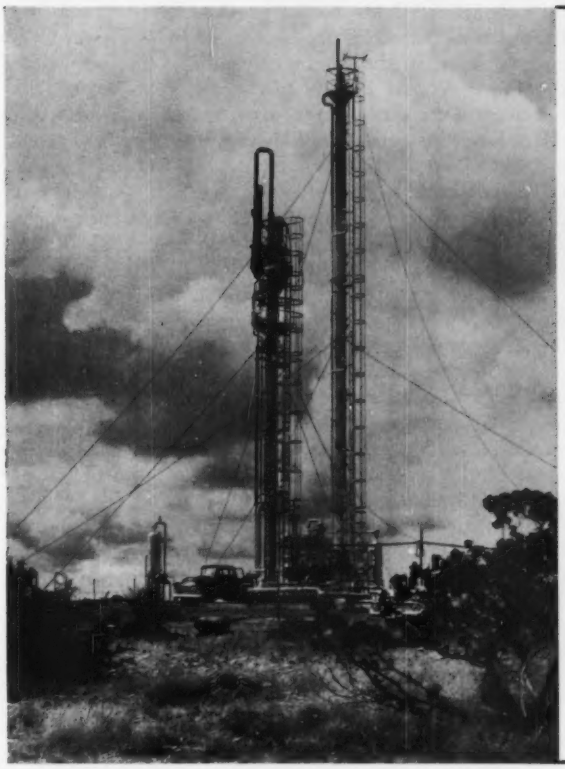
Perhaps the most economic regeneration procedure, where a very low CO_2 concentration in the product gas is required, is to use air stripping to remove the CO_2 followed by vacuum flashing to remove dissolved oxygen. In this case, only a minor amount of power is required in the vacuum step because of the very small amount of dissolved air which must be desorbed and compressed to atmospheric pressure.

Gas, which is flashed off in the intermediate pressure flash step, is rich in hydrocarbons and may be handled in a number of ways. Recycle to the bottom of the absorber, as shown in the flow diagram, is perhaps the simplest if the gas cannot be used locally as a low Btu fuel. The theoretical efficiency of the recycle step can be improved by feeding the recycle gas into the absorber at a point below the main gas inlet. This results in a reduction in required solution flow rate at the expense of absorber height.

Alternatively, the intermediate pressure flash gas may be contacted with a separate stream of solvent before recycle, and then admitted to the primary absorber at a point above the main gas inlet. This system results in a smaller recycle compressor (because most of the CO_2 is removed before compression) and reduces the size of the primary absorber by reducing the required liquid rate and decreasing the gas velocity at the bottom of the absorber where gas flow rate normally is highest. Over-all hydrocarbon recoveries on the order of 98 per cent are readily attained using recycle schemes such as described above.

Details of the flow scheme may be varied to permit operation at the temperature level which is optimum for any particular set of conditions. When subambient temperature operation offers advantages, it is generally necessary to extract heat from the system at one or more points and it is most economical to remove the heat from relatively warm streams. Typically, this is accomplished by the use of heat exchangers for cooling the rich solution from the absorber, the feed gas, and the recycle gas after compression. If a relatively low temperature level is desired, it often is economical to use the cold product gas and CO_2 streams as coolants, while the use of cooling water may be adequate for operation near ambient temperature.

In the flow arrangement illustrated, a hydraulic turbine is employed to extract energy from the solvent during pressure reduction from the intermediate flash pressure to atmospheric pressure. Depending upon economics, turbines may also be justified to remove work



This large pilot plant was built by El Paso Natural in Terrell County to study process variables.

Patents and Pilot Plant

Patent applications were filed on many features of the process. Three patents recently have been issued[1,2,3] which cover the solvents propylene carbonate, glycerol triacetate, butoxy diethylene glycol acetate and methoxy triethylene glycol acetate when used for the absorption of carbon dioxide from high pressure gas streams. Several process flow schemes also are described.

The El Paso Natural Gas Company joined Fluor in the commercial development of the process for application to a natural gas containing a very high carbon dioxide concentration. Additional bench-scale tests were conducted to duplicate the expected field conditions and then a large field pilot plant was constructed by the El Paso Natural Gas Company in Terrell County, in west Texas.

The field pilot plant, which had a nominal capacity of approximately 1.5 MMscfd of input gas, was found capable of reducing the carbon dioxide content of the gas from about 53 percent to less than 3 percent without the use of vacuum or stripping vapor in the regeneration step and to less than 0.25 percent when air stripping was employed. The effects of such variables as absorber height, operating temperature, flow arrangement, and nature of solvents were investigated in this plant. In general, process performance checked remarkably well with that predicted from the bench-scale studies and provided firm design data for commercial plants.

energy during the initial pressure reduction or between intermediate flash stages, if these are used. Additional energy recovery may be obtained by passing gases, flashed from the solution at intermediate pressures, through a gas expansion turbine.

Process Economics. The Fluor Solvent CO_2 Removal Process is intended primarily for the purification of gases containing CO_2 in high concentrations at high pressures. Hydrogen sulfide and mercaptans do not interfere with the process and, in fact, simultaneous removal of an appreciable percentage of these impurities with the CO_2 is realized. The process is most economical for gas streams which are quite dry with regard to heavier hydrocarbons because of the solubility of these components in the solvents used. Absorbed methane and ethane can be largely recovered by the intermediate flash and recycle but an appreciable portion of the propane and heavier hydrocarbons may be lost with the carbon dioxide unless special steps are taken to recover them. Since these steps add to the plant costs, the process becomes less attractive for "wet" gas streams. Hydrogen and nitrogen are very sparingly soluble in the solvents so the process is very attractive for synthesis gas purification where sufficiently high CO_2 partial pressures are encountered.

To illustrate the advantage of the new process in one application, an economic comparison of the Fluor Solvent CO_2 Removal Process with the hot potassium carbonate, Giammarco-Vetrocoke, and water wash processes has been made. Plants have been designed to use each of these processes for purifying the same high CO_2 natural gas stream, and first cost and operating costs have been estimated for each. Operating conditions and requirements which form the basis of the plant designs are given in Table 1.

It will be noted that the gas is quite dry with regard to heavy hydrocarbons, and is free of H_2S and mercaptans. This composition was chosen to simplify the analysis; however, the results would not be greatly altered by a minor increase in the quantity of ethane and heavier hydrocarbons, or by the presence of a small amount of sulfur compounds. The feed gas contains 53.2 percent CO_2 and has a 70° F water dew point. All of the plants were designed to produce a treated gas containing 2 percent CO_2 with a maximum water dew point of 32° F. Under the conditions of this example, the Fluor Solvent Process does an adequate dehydration job, while all of the others add water to the gas and, therefore, require separate dehydration steps. The

TABLE 1—Plant Specifications for Comparing CO_2 Removal Processes

Plant Capacity	110 MMSCF/D Feed Gas
Feed Gas Pressure	800 psig
Feed Gas Composition:	
CO_2	53.2 Percent by volume
N_2	0.7 Percent by volume
CH_4	45.7 Percent by volume
C_2H_6	0.4 Percent by volume
H_2S	nil
Mercaptan	nil
H_2O	70° F. Dew Point
Treated Gas Specifications:	
CO_2	2 Percent Maximum
H_2O	32° F. Maximum Dew Point

cost of these dehydration units is included. Detailed flow diagrams of the hot potassium carbonate, Giammarco-Vetrocoke, and water wash processes are not presented because these processes have been adequately described in previous publications.[4, 5, 6]

The basis for estimating treating costs by the various processes is presented in Table 2 and results of the economic comparison are summarized in Table 3. For the case considered, the Fluor Solvent Process is appreciably more economical than any of the others with regard to both plant investment and operating cost, and the Giammarco-Vetrocoke process is second with regard to both items. The Hot Potassium Carbonate Process shows the next lowest plant investment cost, but it is less economical than the water wash process with regard to total operating cost. The indicated treating costs vary from a low of 2.0 cents/1,000 cubic feet of feed gas for the Fluor Solvent Process to a high of 4.3 cents for the Hot Potassium Carbonate Process. It should be noted that a fifth process, the well-known monoethanolamine process, could also be used for the required gas purification; however, previous studies have indicated that it would not be competitive with even the hot potassium carbonate or water wash processes for the case studied.

Both the feed composition and product gas specifications have a major effect on plant costs and, in fact, on establishing the optimum process. For example, the Giammarco-Vetrocoke process can provide a lower CO_2 concentration in the product at little extra cost, while the Fluor Solvent Process might require a second gas purification step or a more expensive solvent stripping operation if an appreciably lower product gas CO_2 content is required. On the other hand, if the product gas CO_2 specification is relaxed (to say, 3 percent CO_2), the Fluor Solvent Process becomes even more attractive because the vacuum flash step used in the case studied could be omitted.

At higher CO_2 partial pressures in the feed gas, the Fluor Solvent Process shows a greater advantage over the other processes studied and, at lower CO_2 partial pressures, the Giammarco-Vetrocoke process becomes progressively more attractive. Preliminary analysis indicates that the Fluor Solvent Process would continue to be the most economical method for removing CO_2 from a gas of the type studied down to a CO_2 partial pressure of less than one-half that used in the example.

If other conditions are not changed, the presence of H_2S in the feed gas favors the Fluor Solvent Process over Giammarco-Vetrocoke because the latter requires that H_2S be removed in separate additional equipment ahead of the CO_2 removal unit. The presence of heavy hydrocarbons in the gas, on the other hand, swings the economic advantage toward Giammarco-Vetrocoke.

Original presentation was before the NGAA, Houston, April 27-29, 1960.

TABLE 2—Basis for Estimating Plant Operating Costs

	Direct Costs
Fuel Gas	$0.16/MM Btu
Process Water	0.10/M Gal.
Chemical Losses	Current Prices.
Operating Labor	Operators $2.75/hr; Foreman $3.50/hr; Plus 22 percent burden to cover insurance, vacation and other benefits.
Maintenance	Annually 4 percent of plant investment; typically 60 percent labor and 40 percent materials.
Plant General	Annually 40 percent of total direct labor cost, includes nonoperating services and personnel up to and including plant manager.
	Indirect Costs
Depreciation	Annually 10 percent of plant cost.
Taxes and Insurance	Annually 2.5 percent of plant cost.
Interest	Annually 3 percent of plant cost.

TABLE 3—Economic Comparison of Treating Processes

	Fluor Solvent	Giammarco-Vetrocoke (Air Stripped)	Hot Potassium Carbonate	Water Wash
Plant Investment*	**$2,400,000**	**$3,900,000**	**$4,600,000**	**$4,800,000**
Direct Operating Costs				
Fuel Gas	130,000	90,000	590,000	206,000
Process Water	1,000	5,000	2,000	1,000
Chemical Losses	18,000	10,000	6,000	1,000
Operating Labor	96,000	96,000	96,000	96,000
Maintenance	104,000	156,000	172,000	192,000
Plant General	62,000	74,000	78,000	83,000
Total Direct Costs	411,000	431,000	944,000	579,000
Indirect Operating Costs				
Depreciation	240,000	390,000	460,000	480,000
Taxes and Insurance	60,000	98,000	115,000	120,000
Interest	72,000	117,000	138,000	144,000
Total Indirect Costs	372,000	605,000	713,000	744,000
Total Operating Costs	783,000	1,036,000	1,657,000	1,323,000
Treating Costs, $/MSCF Feed	**$0.020**	**$0.027**	**$0.043**	**$0.034**

* Includes royalty and initial chemical charge.

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[6] Kohl, A. L. and F. C. Riesenfeld, "Gas Purification," McGraw-Hill Book Company, New York, New York, 1960.

About the Authors

Kohl

Arthur L. Kohl is chief research engineer for the Fluor Corporation, Ltd. He received both his bachelor's and master's degrees from the University of Southern California in chemical engineering. He worked in research and development for Turco Products and served in the Army prior to joining Fluor in 1947. Kohl conceived and supervised the development of this new process.

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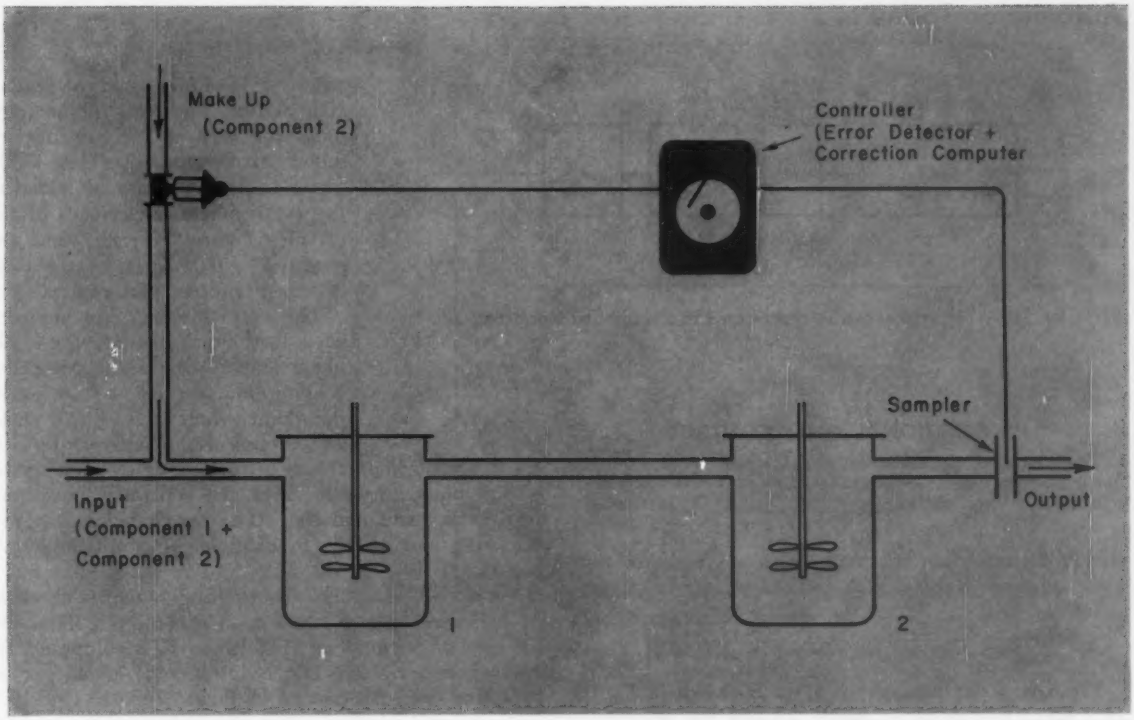

FIGURE 139—The example problem will be similar to the one used in Part 18 of this series.

PART 21

Automation Today

Now the analyst is prepared to make a complete design of a control system to meet certain specifications. Test your understanding by following the example problems given here

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THE PREVIOUS two parts of this series have covered the rules for sketching in rough form the root locus for any pole-zero configuration, that is, for any system whose transfer function is known. Various methods of refining the resulting rough root locus to obtain any accurate plot in regions of special interest were presented. These latter methods of plotting allow the complete analysis of a control system to any degree of accuracy necessary. With this background, the analyst is now prepared to "tackle" the complete design for a control system to meet certain specifications.

EXAMPLE PROBLEM

Let us use for discussion an example similar to the one used in Part 18 of this series. The specific system is shown in Figure 139, and represented in block diagram form in Figure 140. It consists of two different sized kettles in cascade with the fractional composition of a particular component being sampled at the output of the second kettle and compared to the set point value to determine the process error.

Our task here is then to determine by root-locus methods the best type of controller to apply to the system to yield a good transient response with a minimum overshoot. The time constants of the kettles and the valve have been computed in the normal way and were found to be $T_1 = 0.5$, $T_2 = 0.25$, and $T_3 = .0050$ time units respectively.

The transfer function of the plant then becomes:

$$G(p) = \left[\begin{matrix}\text{Transfer function} \\ \text{of Controller}\end{matrix}\right] \left[\frac{1}{(T_1 p + 1)\,(T_2 p + 1)\,(T_3 p + 1)}\right] \qquad (1)$$

T_3 may be disregarded in the design of the control system for this example because $T_3 << T_1$ or T_2.

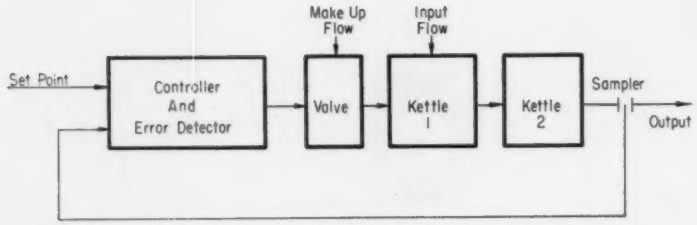

FIGURE 140—The system can be represented in a simplified block diagram.

PROPORTIONAL ONLY CONTROL

The reduced equation for the system:

$$G(p) = \frac{K}{(T_1 p + 1)(T_2 p + 1)} \qquad (2)$$

should be rewritten in the ω form to facilitate root locus plotting. Replacing T by $1/\omega$ yields:

$$G(p) = \frac{K \omega_1 \omega_2}{(p + \omega_1)(p + \omega_2)} = \frac{K\,(2)\,(4)}{(P + 2)\,(p + 4)} \qquad (3)$$

The root locus plot for G(p) is as shown in Figure 141. Since the standard design criteria for good control is that $\delta = 0.36$, we must draw in the $\delta = 0.36$ line (at an angle of 69°) to allow the computation of the proper K to yield the optimum transient response. The value of K from the root locus is found to be $K = (7.65)\,(7.65)/(2)\,(4) = 7.32$.

PROPORTIONAL PLUS INTEGRAL CONTROL

Using the procedure outlined in Parts 19 and 20, the optimum integral (reset) control may be established for this system. The proportional plus integral expression is normally taken to be:

$$G_I(p) = K\left(\frac{T_I p + 1}{\beta T_I p + 1}\right) = \frac{K}{\beta}\left(\frac{p + \omega_I}{p + \omega_I/\beta}\right) \qquad (4)$$

where β is of the order of magnitude of 10.0. The —90° phase angle locus for such a lag controller is shown in Figure 142. This —90° phase angle locus must be added to the —90° phase angle locus of the system (Figure 143) to yield the required —180° locus of the total system of process plus controller.

The correct values are obtained when the following occurs: the —90° phase angle locus of the controller is asymptotic to the $\delta = 0.36$ line at the point where the —90° phase angle locus of the system intersects the $\delta = 0.36$ line. This is accomplished by moving the —90° phase angle locus of the controller back and forth along the real axis (i.e., by changing ω_I) and adjusting its size (i.e., by changing β) until the above occurs.

Figure 144 diagrams the resulting system. The value of ω_I is seen to be 9.3 and of ω_I/β to be 0.3. Thus the required β is equal to 31.0. When K is computed, its value becomes 7.58. The resulting root locus for the complete system is plotted in Figure 145.

PROPORTIONAL PLUS DERIVATIVE CONTROL

As mentioned in earlier articles, the proportional plus derivative (i.e., rate) control mode can be expressed as:

$$G_d(p) = K\left(\frac{T_d p + 1}{\alpha T_d p + 1}\right) = \frac{K}{\alpha}\left(\frac{p + \omega_d}{p + \omega_d/\alpha}\right) \qquad (5)$$

where α is usually of the order of 0.1 and ω_d must be determined just as in the case of the lag controller in order to yield the optimum transient response.

To proceed by the same method as described for the lag controller above, it would be necessary to plot the —270° phase angle locus of the system without a controller. This is shown in Figure 143. The +90°

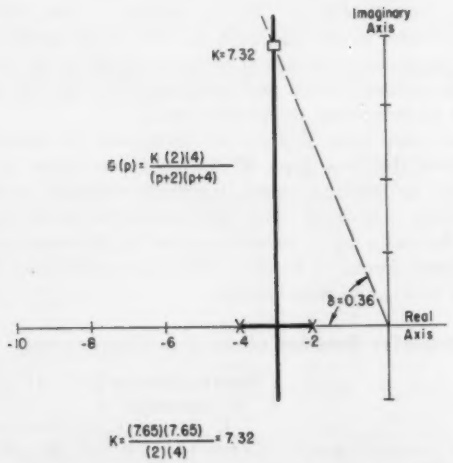

FIGURE 141—A root locus plot is made to show the proper gain with proportional control.

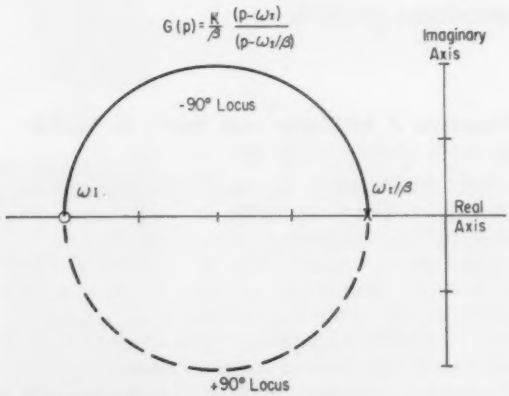

FIGURE 142—The phase angle locus of a lag controller is represented by a circle.

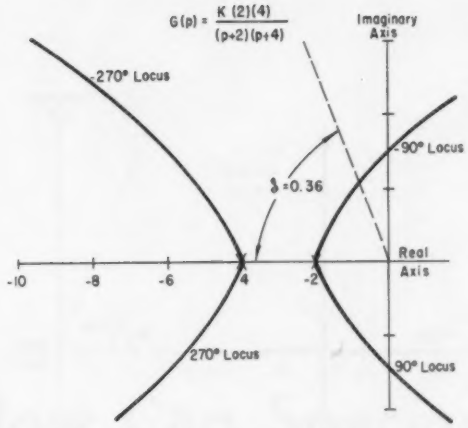

FIGURE 143—Here is the phase angle locus for the example system.

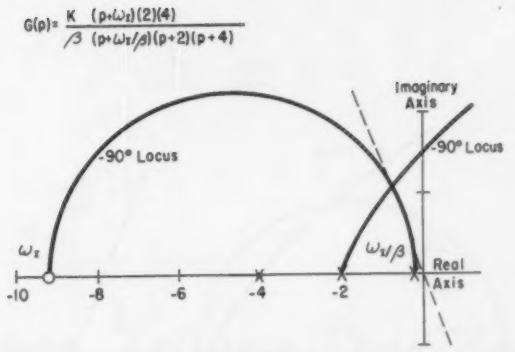

FIGURE 144—The –90-degree phase angle locus of the controller is added to the –90-degree phase angle locus of the system. They are made to coincide at the 69-degree asymptote.

phase angle loci of the controller is then plotted on the same graph (Figure 146) along with the $\delta = 0.36$ line.

Now normally the $+ 90°$ phase angle locus of the controller would be moved back and forth and adjusted in size until it was asymptotic to the $\delta = 0.36$ line at the point where this latter line intersected the $-270°$ phase locus of the process. However, for the process example presented here, this is impossible because the $-270°$ phase angle locus of the process and the $\delta = 0.36$ line will never intersect. Therefore, another criterion must be chosen.

The reader will recall from our discussion in Part 3 of this series (PETROLEUM REFINER, June 1956, pp. 141-144) an often used criteria is to let the numerator time constant of the derivative controller equal the largest time constant of the process. Then we effectively cancel out this time constant and replace it with the much smaller denominator time constant of the controller.

In root locus terms, this would mean let the zero of the controller exactly match the farthest right hand pole of the process system. That is, let $\omega_d = 2.0$. We have thus converted our system to one with effectively no zeroes and only two poles at -4 and at -10, if we let $\alpha = 0.2$. The resulting system is shown in Figure 147. The value of K for such a system is 139.2.

PROPORTIONAL PLUS RATE PLUS RESET CONTROL

As we have learned previously, all three modes of control can be combined to yield a better over-all control system. The individual locations of ω_d and ω_I can be established individually as above. It is then a relatively simple matter to construct the complete root-locus to include both the lead and lag compensation.

Let us take our original system with poles at -2, and -4, and add an integral or lag controller with ω_I of 8.2 and β of 41. Also add a rate or derivative controller with $\omega_d = 3.5$ and $\alpha = 0.29$. This will not necessarily be the optimum system in view of our previous values of ω_I, β, ω_d, and α but will better illustrate the type of plot we desire to obtain.

The composite root locus is shown in Figure 148. Notice that this system is stable for all values of K. However, K for a $\delta = 0.36$ can be found from the plot in the same manner as before, i.e.,

$$G(p) = \frac{K\,(p+\omega_1)\,(p+\omega_d)\,(1/T_1)\,(1/T_2)\left(\frac{\omega_I}{\beta}\right)\left(\frac{\omega_d}{\alpha}\right)}{(p+1/T_1)\,(p+1/T_2)\left(p+\frac{\omega_I}{\beta}\right)(p+\omega_d/\alpha)\,(\omega_I)\,(\omega_d)} \qquad (6)$$

and

$$K = \frac{(Gp)\,(p+1/T_1)\,(p+1/T_2)\,(p+\omega_I/\beta)\,(p+\omega_d/\alpha)\,(\omega_I)\,(\omega_d)}{(p+\omega_1)\,(p+\omega_d)\,(1/T_1)\,(1/T_2)\,(\omega_I/\beta)\,(\omega_d/\alpha)} \qquad (7)$$

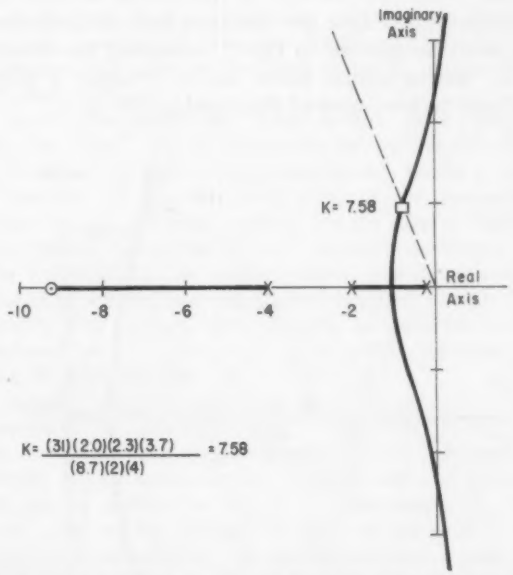

FIGURE 145—Here is the root locus plot for the complete system including a reset controller (proportional plus integral control).

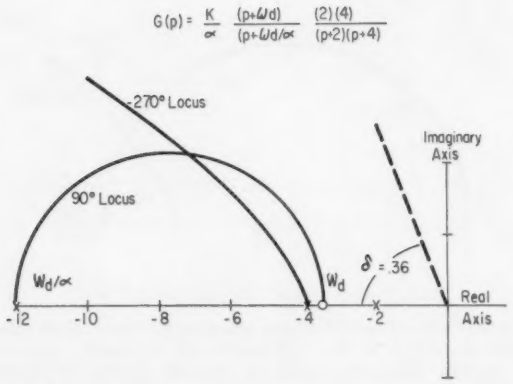

FIGURE 146—The phase angle locus of the system is added to the phase angle locus of a rate controller (proportional plus derivative control).

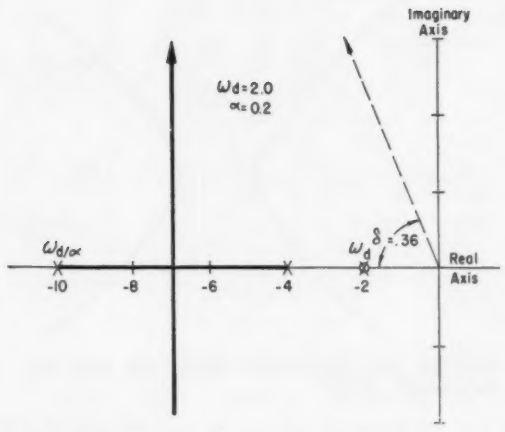

FIGURE 147—Here is the root locus plot for the system using a rate controller.

where K is evaluated at $G(p) = -1$, and only the magnitude of K is considered. Therefore, the solution for K in the example is as follows:

$$K = \frac{(1.0)\ (5.1)\ (5.4)\ (5.4)\ (11.3)\ (8.2)\ (3.5)}{(8.0)\ (5.3)\ (2.0)\ (4.0)\ (0.2)\ (12.0)} = 59.1 \qquad (8)$$

A COMPARISON OF THE ROOT LOCUS WITH OTHER METHODS

The reader may recall that essentially the same example as that discussed in this article has been previously discussed in Part 3 (PETROLEUM REFINER, June 1956, pp. 141-144) and Part 6 (PETROLEUM REFINER, September 1956, pp. 337-340) of this series. It will be interesting to see how the root-locus method illustrates the points brought out in Part 3 concerning the effects of the various control modes and to compare it with the Bode diagram method illustrated in Part 6.

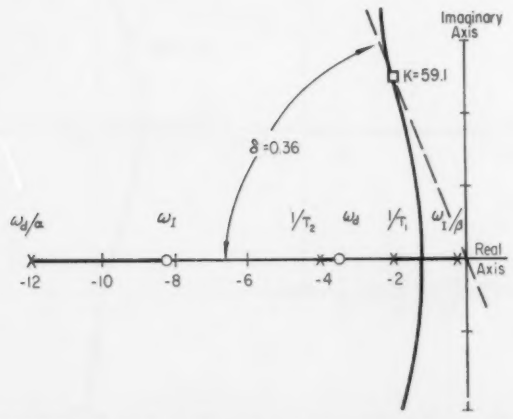

FIGURE 148—All three modes of control can be combined to yield a better over-all control system. Here is a root locus plot for the system including proportional rate-reset control.

In Part 3 we illustrated by means of the transfer function equations and sketches that the usual effect of derivative or rate control was that of speeding up the system. This was equivalent to substituting a smaller stirred pot for one of those present. Inspection of Figure 147 in comparison to Figure 141 and Figure 148 versus Figure 145 shows that derivative control effectively moves the root locus toward the left for larger values for the poles, or equivalently smaller time constants and a faster responding system. On the other hand, integral control moves the root locus toward the right (Figure 145 versus Figure 141) or toward more sluggish response.

In addition, though, the root locus graphically illustrates the fact that integral control can be unstable, if the gain is too high (by having the locus enter the right-half plane) and gives a means for readily calculating the gain value which will cause this instability. The Bode diagram has this same facility of permitting calculation of gain for imminent instability, but the fact of possible instability is not so graphically presented.

The example used with the Bode diagram method in Part 6 of this series included the concept of dead time, or true time delay, and its effect upon control. This was not included on the present example, because dead time can only be approximated on the root locus and then only by a quite complex method.[1] The Bode diagram is, therefore, recommended for those cases where dead time or true time delay is an important factor. Presence of the dead time resulted in different and much smaller maximum gains for the case of Part 6 than for the present example.

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TO BE CONTINUED

How Cap Spacing Sets Tower Design

Some design methods set the diameter of bubble cap columns without regard for the cap sizes or spacing. But here is a method that includes these important features

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HERE IS A NEW METHOD for determining the maximum vapor or gas capacity of bubble cap towers. The method combines the main features of bubble cap tray design into two mathematical expressions. These expressions can be used then to design new towers or to test the loading of existing towers.

The method derives equations for optimum bubble cap spacing at total cap slot opening based on correlations of Kirschbaum[3] and Zenz.[4,5] The choice of adequate cap spacing is based on limits which have proved suitable in practice.

Two essentially new methods have been published since the Second World War for the determination of bubble cap column diameters.

The method of the first type is that developed by Davies.[1] The factor F, introduced by him, which denotes the product of the vapor velocity and the square root of vapor density, renders possible the determination of empty column diameter by adopting for factor F the value of approximately 1.1 in distillation, and about 0.8 in absorption. It is also emphasized by Davies in one of his later papers,[2] that the column diameter determined on the basis of factor F must be verified in later phases of the design by trial and error method, because the vapor capacity of the column is determined in the first place not by the cross section of the empty column, but by the number and sizes of the caps and slots to be placed on the trays.

Walsh and Lafyatis, working according to Davies' method, recommend in a paper appeared recently[9] to determine the value of the Davis factor F, on the basis of plate resistance.

Bolles also utilizes the Davies method in a comprehensive paper[11] for the determination of the diameter of bubble cap towers, emphasizing the necessity and importance of allround verification of the calculated value by trial and error method. On the basis of Davies' correlations, a diagram series[12] has been developed by the authors of the present paper, providing a new graphical method for the dimensioning of bubble cap towers. The trial and error method, necessitated by the assumed value of factor F, is considerably shortened by this diagram series.

Another way to determine the cross section of the column is the method by Zenz.[4,5] According to this, the starting point for the determination of the cross section should be the maximum slot velocity, and the number of caps of similar size should be determined. To the area required for efficient working of the number of caps thus calculated, the downcomer areas must be added, in addition to about 20% for the dead space occurring at the weir as well as at the column walls. The cross section thus obtained must also account for

other items, such as pressure drop, vapor distribution, liquid residence time, or liquid gradient. The method recommended by Atkins[7] is essentially along the same lines.

A similar method has been developed by Munk.[8] Operating charts have been published by him for caps having 3, 4, and 6 in. diameters, by means of which the required column cross section may be established.

The value of superficial vapor velocity is considered a function of the cap diameter, the cap spacing, and the densities of both the vapor and the liquid in the latest paper by Kirschbaum.[10] This occupies an intermediate position between the two design methods by further developing Davies' procedure.

As regards cap spacing, literature data differ considerably. Davies[2] says: ". . . the greatest horizontal distance from the slots that the bubbles reach is not over 1 inch." Kirschbaum[3] gives the results obtained in cap spacing determinations. He draws the attention to the fact, that an annular area penetrated by bubbles is developed around the caps, the size of which is a function of cap dimensions and velocity. No correlation was established however with universal validity from his experiments.

In the papers by Zenz[4,5] it is considered a practical principle of general application that the annular area mentioned by Kirschbaum should be twice the slot area. The handbooks by Perry[13] and Ullmann[14] also mentioned the importance of cap spacing only in a general way. According to Van Winkle, with caps of small (1-3 in.) diameters, the distance between the riser centers should be twice the cap diameters. In the case of caps with larger diameters, the suitable value for cap spacing is between 2 and 4 in. Only general mention is made by Bolles[11] in connection with this problem, viz. the cap spacing is 1-3 in. depending on the vapor velocity, but the established values for cap spacings must be subsequently verified from the viewpoint of hydraulic gradient.

As long as wide discrepancies exist among data published in the literature, the choice of a method is entirely at the discretion of the designer. The authors adopted the conception of Kirschbaum[3] and Zenz[4,5] as basis for their further considerations, as this has deemed the most expedient principle for general practice.

Theoretical conclusions resulting from the adoption as a working basis of the conception of Kirschbaum and Zenz, will be developed now.

PRELIMINARY MATHEMATICAL CONSIDERATIONS

The vapor passing through bubble caps displaces the liquid near the sides of the caps, thus "opening" the slots more or less. The amount of vapor required for total opening of slots of heights H_s, on the basis of experiments by Rogers and Thiele,[13] will be:

$$V_m = CA_s\sqrt{H_s\frac{\rho_L-\rho_V}{\rho_V}} \qquad (1)$$

If the vapor velocity is smaller than the velocity defined by Equation 1, the slots are opened only to the height h_s. In case of rectangular slots, the quantity of vapor required is:

$$V = C\frac{A_s}{H_s}\sqrt{\frac{\rho_L-\rho_V}{\rho_V}}\,h_s^{3/2} \qquad (2)$$

The same equation for triangular slots is:

$$V = C\frac{A_s}{H_s^2}\sqrt{\frac{\rho_L-\rho_V}{\rho_V}}\,h_s^{5/2} \qquad (3)$$

The amount of vapor opening the slots to a height of h_s for trapezoidal slots, if the width of the lower edge of the trapeze is twice its upper edge, may be expressed by a more complicated equation.

$$V = C\frac{A_s}{H_s}\sqrt{\frac{\rho_L-\rho_V}{\rho_V}}\left[0.714\,h_s^{3/2}+0.286\,\frac{(h_s)^{5/2}}{H_s}\right] \qquad (4)$$

Dividing Equations 2, 3, and 4, by Equation 1, we have for rectangular slots

$$\frac{V}{V_m}=\frac{F}{F_m}=\left[\frac{h_s}{H_s}\right]^{3/2} \qquad (5)$$

for triangular slots

$$\frac{V}{V_m}=\frac{F}{F_m}=\left[\frac{h_s}{H_s}\right]^{5/2} \qquad (6)$$

and for trapezoidal slots

$$\frac{V}{V_m}=\frac{F}{F_m}=0.714\left[\frac{h_s}{H_s}\right]^{3/2}+0.286\left[\frac{h_s}{H_s}\right]^{5/2} \qquad (7)$$

Equations 5 through 7 may be used for the calculation of h_s by comparing the actual vapor rate with the rate required to achieve total slot opening. Quick solution of the same equations can be obtained from the illustrative diagrams by Bolles.[11]

The foregoing Equations 1 through 7 are necessary for control calculations covering the vapor capacity of a column, but they do not provide information on cap spacing.

To determine the cap spacing necessary at total opening of the slots, an analytical expression of the practical rule disclosed by Zenz,[4,5] has proved advisable.

Let the distance of cap centers be (a) (d_c), the cap spacing is $d_c(a-1)$. The correlation between the annular area, penetrated by bubbles, mentioned by Kirschbaum[3] and the slot area is:

$$\frac{(N)\ (a^2-1)\ (d_c)^2\ (\pi)}{(4)\ (144)}=2\ (A_s)=\frac{(2)\ (N)\ (W)\ (H_s)}{144}=\frac{(2)\ (N)\ (d_c)\ (\pi)\ (H_s)\ (x)}{144} \qquad (8)$$

In Equation 8, W is the average width measured at half of the total slot height, and is independent of the slot shape, whether rectangular, trapezoidal, or triangular. As to the Value of $x = W/(\pi)\ (d_c)$, it must be mentioned that if the slot width is the same as that of the

teeth, x = 0.50. In designing a new column, the value of x is generally taken to be 0.50. However, in controlling the maximum vapor capacity of an existing column, the actual ratio $W/(\pi)\ (d_c)$ must be taken into account.

From Equation 8

$$a^2 - 1 = \left(\frac{8}{d_c}\right)(H_s)\ (x). \tag{9}$$

Then

$$a = \sqrt{\left(\frac{8}{d_c}\right)(H_s)\ (x) + 1}. \tag{10}$$

The minimum spacing, required in the case of maximum vapor quantity totally opening slots of any shape, may be calculated from Equation 10 as a function of cap and slot dimensions.

In order to facilitate ready perception of the matter, cap spacing values for the most generally required case x = 0.50 are compiled in Table 1.

TABLE 1—Factors for Bubble Cap Spacing

	PITCH FACTOR a for given d_c			CAP SPACING, $d_c\ (a-1)$ for given d_c		
H_s	3"	4"	6"	3"	4"	6"
1.00.....	1.52	1.42	1.30	1.56	1.68	1.80
1.25.....	1.675	1.50	1.35	1.91	2.00	2.10
1.50.....	.....	1.58	1.42	....	2.32	2.52

Equation 10 is of general validity, however an equation showing the correlation between the numerical values of the maximum vapor quantity and the cap spacing is also required. On our considerations in connection with establishing the wanted correlation covers the equilateral triangular allocation mostly used in practice. In that case the sides of triangles, (a) (d), an allocated area of

$$A = (N)\left(\frac{0.785}{0.906}\right)\left(\frac{a^2\ d_c^2}{144}\right) \tag{11}$$

is required for operating N caps.
From this equation

$$\frac{A}{A_c} = \frac{a^2}{0.906} \tag{12}$$

Introducing the following reduction:

$d_R = (K_1)\ (d_c)$, hence $A_R = (K_1)^2\ (A_c)$. Then

$$\frac{A}{A_c} = K_1^2\left(\frac{A}{A_R}\right) \tag{13}$$

Upon substitution of Equations 11 and 12 into Equation 13, the number of caps per tray may be determined from the total riser cross sections and the cap diameter

$$N = \frac{(144)\ (A_R)}{(K_1)^2\ (0.785)\ (d_c)^2} \tag{14}$$

Substituting Equations 8 and 14 into Equation 1, the maximum vapor quantity necessary for total slot opening is obtained:

$$V_m = (K)\ (C)\ (A_R)\ (a^2 - 1)\sqrt{(H_s)\frac{\rho_L - \rho_V}{\rho_V}} \tag{15}$$

In practice, the value of ρ_V may be neglected in most cases as compared with ρ_L. Also, dividing both sides of Equation 15 by A_T, a detailed analytical expression of factor F is obtained, whereby

$$F_m = u_m\sqrt{\rho_V} = (K)\ (C)\left(\frac{A_R}{A_T}\right)(a^2 - 1)\sqrt{(H_s)\ (\rho_L)} \tag{16}$$

The values of constant C in Equations 15 and 16 are as follows:

Slot Shape	C
triangular	0.63
trapezoidal	0.74
rectangular	0.79

The maximum slot velocity can also be calculated from Equation 16, since

$$u_m' = \frac{(u_m)\ (A_T)}{A_s} = (K)\ (C)\ (a^2 - 1)\left(\frac{A_R}{A_s}\right)\sqrt{(H_s)\left(\frac{\rho_L}{\rho_V}\right)} \tag{17}$$

For the factor $(K)\left(\frac{A_R}{A_s}\right)$ in Equation 17, it can be shown that

$$(K)\left(\frac{A_R}{A_s}\right) = \frac{d_c}{(8)\ (H_s)\ (x)} \tag{18}$$

According to this, Equation 17 will be transformed into

$$u_m' = \frac{(C)\ (d_c)}{(8)\ (x)}(a^2 - 1)\sqrt{\left(\frac{1}{H_s}\right)\left(\frac{\rho_L}{\rho_V}\right)} \tag{19}$$

For the maximum slot velocity calculated as per the total slot area for each tray, the following correlation is given by Davies,[2] followed also by a same correlation by Treybal:[16]

$$F_m' = u_m'\sqrt{\rho_V} = 12 \tag{20}$$

Comparing Equation 19 with Equation 20, we have

$$F_m' = \frac{(C)\ (d_c)}{(8)\ (x)}(a^2 - 1)\sqrt{\frac{\rho_L}{H_s}} \tag{21}$$

The above derived correlations for the determination of cap spacing are based on the communication by Zenz,[4, 5] covering the slot area and the annular area around the caps, penetrated by vapor bubbles. To verify the fundamental assumption made by Zenz, the method by Dauphine[16] was chosen. According to Dauphine, the

maximum slot velocity allowable from the viewpoint of entrainment can be expressed by the following equation:

$$u_m' = 1.44\sqrt{\frac{\rho_L}{\rho_V}} \qquad (22)$$

From Equations 19 and 22

$$\frac{(C)\ (d_c)}{(8)\ (x)}\left(\frac{a^2-1}{\sqrt{H_s}}\right) = 1.44 \qquad (23)$$

Since we have from Equation 9

$$\frac{d_c}{8x} = \frac{H_s}{a^2-1}$$

According to Equation 23, the following equation should hold good

$$C\sqrt{H_s} = 1.44 \qquad (24)$$

As hardly any slots higher than 1.5 in., and none exceeding 2.0 in. are used in practice, and the value of C being smaller than 1, the maximum slot velocity calculated from Equation 19 is always smaller than the slot velocity considered permissible by Dauphine from the viewpoint of entrainment.

CONCLUSIONS DRAWN FROM EQUATIONS 16 THROUGH 24

The Equations 16-24, communicated in this article, represent a further development in the problem of the determination of the allowable vapor/gas velocity in bubble cap towers. Studying the correlations disclosed in the above, important conclusions for the practice may be drawn from them. These conclusions, listed in the order of the equations, are as follows:

- Equation 16 proves, that the Davies factor F is not an arbitrary factor, but it is the function of the constructional elements of bubble caps (cap, riser, slot, spacing) and the density of vapor and liquid to be separated.
- Equation 16 provides a theoretical verification of the practice, according to which the maximum linear gas velocity in absorbers is approximately 75 percent of the vapor velocity used in distillation columns. Detailed explanation of this statement is given in the following: The ratio $\frac{A_R}{A_T}$ in equation 16 may be considered a recognized index, for which various values are recommended in the literature. It generally amounts to 8-16 percent by distillation and 6-12 percent by absorption. The reason for this is that by absorption the ratio $\frac{L}{G}$ is usually larger than by distillation. It follows, that by absorption the ratio $\frac{A_L}{A_T}$ is also larger, and ratio $\frac{A_R}{A_T}$ smaller than by distillation. If the other values are constant, decreasing of ratio $\frac{A_R}{A_T}$ involves the decrease of linear vapor velocity. Such investigations of Equation 16 thus provide full explanation of the maximum gas velocity attainable in absorbers, as against the publications in the technical literature, explaining the smaller gas velocity by absorption on the basis of the importance of entrainment reduction.
- Since the term (a^2-1) is introduced into Equation 16 from Equation 9, the practical experience that the so-called vapor capacity of a cap with smaller diameter is larger than that of a cap with a larger diameter is also expressed by Equation 16.
- In accordance with the foregoing statement, Equation 19 is the analytical expression of the practical experience, proved by the investigation of Kirschbaum,[3] viz. that increasing the cap diameter and the cap spacing, the slot velocity also increases.
- As proved by Equation 21, the factor F_m' recommended by Davies for the determination of maximum slot velocity, is by no means a constant, but it is a function of the cap and slot dimensions, the cap spacing, and the liquid density, as is the case with factor F_m.
- It is apparent from Equations 23 and 24, that Equation 16 and the equations derived from them provide a maximum slot velocity value, safe also with a view to entrainment.

FURTHER DEVELOPMENT OF THE EQUATIONS

Equation (16) and the equations derived from it possess great theoretical value, as has been enumerated. By these equations, the approved practice as regards superficial linear velocity in bubble cap distillation columns and absorbers is justified in analytical expression, and the maximum velocity of vapor passing the slots is determined. Besides, it is now possible to assume that in the determination of the maximum slot velocity, the entrainment is not the limiting factor.

Furthermore, it must be mentioned, that in Equation (16), the terms $\frac{A_R}{A_T}$ and (a^2-1) are not independent from one another. As a result of this, when applying Equation (16), the ratio $\frac{A_R}{A_T}$ must be estimated taking into consideration various recommended values. It must be verified, in a subsequent step, whether the aggregate cross sectional area of risers allocable in the column cross section (determined by the calculated factor F_m) corresponds to the estimated value of ratio $\frac{A_R}{A_T}$.

The equations will now be transformed in a way to avoid the foregoing difficulties. First the equation necessary for the determination of the required number of caps may be deduced from Equation (21) as:

$$u_m' = \frac{(C)\ (d_c)}{(8)\ (x)}(a^2-1)\sqrt{\left(\frac{1}{H_s}\right)\left(\frac{\rho_L}{\rho_V}\right)} = \frac{(144)\ (V_m)}{(N)\ (d_c)\ (\pi)\ (H_s)\ (x)} \qquad (25)$$

From Equation (25) we have

$$N = \frac{(366.87)\ (V_m)}{(C)\ (d_c)^2\ (a^2-1)}\sqrt{\left(\frac{1}{H_s}\right)\left(\frac{\rho_V}{\rho_L}\right)} \qquad (26)$$

The cap spacing in Equation (26) must satisfy Equation (10). If the cap spacing is smaller than the value calculated from Equation (10), the column cannot be

operated at a load of V_m. The cap areas occupied per tray will be, from equation (26):

$$A_c = \frac{2\,V_m}{C\,(a^2 - 1)}\sqrt{\left(\frac{1}{H_s}\right)\left(\frac{\rho_V}{\rho_L}\right)} \qquad (27)$$

From Equation (12) and (27) the allocated area per tray, i.e., the area necessary for smooth operation of N caps of diameter d_c is:

$$A = (2.207)\left(\frac{a^2}{a^2 - 1}\right)\left(\frac{V_m}{C}\right)\sqrt{\left(\frac{1}{H_s}\right)\left(\frac{\rho_V}{\rho_L}\right)} \qquad (28)$$

The Equation (26) through (28) thus render possible the determination of the values N, Ac and A, without having to resort to data other than the value of the required maximum vapor capacity, the dimensions of the selected bubble cap type, and the densities of vapor and liquid.

It must be also emphasized in this connection, that if the value "a" to be substituted into Equation (28) corresponds to the selected cap and slot dimensions satisfying equation (10), the slots of the caps working on the surface A, calculated from equation (28), will be completely opened. If however the cap spacing is smaller than the value satisfying Equation (10), the vapor flow opens the slots to a certain extent only and deterioration of plate efficiency must be taken into account.

The allocated area determined by equation (28) is the area required for the passage of vapor bubbles. Since the size of this area is influenced by the cap spacing to a great extent, the cap spacing is considered by the authors of the present paper as the limiting factor in connection with vapor capacity of bubble cap towers.

WHICH METHOD SHOULD BE USED

Selection between the two design methods, described in the publications cited in the first part of this article and dealing with the determination of the cross section of bubble cap towers, remains still an open question, even after the introduction of cap spacing as the factor determining the vapor capacity. In either case, construction of the tray layout is necessary. Then the method to be preferred is the one which gives fewer trial and error operations after dimensions have been assumed or determined.

When determining the cross section by the Davies factor F, the value of F_m, according to Equation (16), must not be estimated in an arbitrary manner. It must be calculated. The values of K, C, a, and H_s in Equation (16) depend on the cap type to be utilized, whereas an arbitrary value must be substituted for the ratio $\frac{A_R}{A_T}$ i.e., within the range of 8-16 percent for distillation and 6-12 percent for absorption. Further calculation is required to establish the number of allocable caps on a tray. The cross section of the tray is determined from factor F_m in accordance with the cap spacing and the ratio $\frac{A_R}{A_T}$ in such a way as to make an adequate area available for the downcomers. The tray cross section and the number of caps, as well as the downcomer areas, must be controlled in the course of design.

Application of the method introduced by Zenz uses the practical experience that the allocated area of the plate cross section generally amounts to 60-70 percent with distillation and to 45-55 percent with absorption as a starting point. If the allocated area per tray is determined, the cross section of the column may be calculated in first approximation by simple division. In the second step, the necessity of checking the allocable number of caps does not arise. The next step will therefore be the design of tray layout and control from many viewpoints. The Davies method necessitates one more calculation operation than the method developed by Zenz, if the allocated area per tray can be directly determined from the initial data and the dimensions of the selected cap type. The authors of the present paper thus prefer the method by Zenz, modified by Equation (28), to that by Davies.

APPLICATION OF THE MODIFIED METHOD

Equation (28) is useful and suitable for both the design of a new column and the control of the maximum vapor capacity of an existing column. For the design of a new column, the following data are required as starting points:

- Vapor quantity rising, cu.ft/hr
- Quantity of liquid flowing downwards, cu.ft/hr
- Density of vapor, lb/cu.ft
- Density of liquid, lb/cu.ft.

Before finally establishing the plate cross section, a cap size must be selected, which represents an optimum for both technical and economical viewpoints. No general rule can be given regarding this selection, and an optimum choice achieved by the least amount of trial and error depends to a great extent on the experience of the designer. The present paper does not deal with this important question.

Cap dimensions must include the following data:

- Outside and inside diameters of cap
- Outside and inside diameters of riser
- Shape of slots. (Highest vapor capacity is found with rectangular slots, whereas a trapezoidal slot responds most readily to vapor load fluctuations. The triangular slot has the smallest capacity.)
- Height of slots
- Width of slots, measured at medium height of slots
- Distance between upper edge of riser and top of cap
- Skirt clearance.

These data applied to Equation (10) gives a value for "a" as a basis for further calculations. Solution of Equation (28) then presents no difficulty.

To obtain the column cross-section, the value of the allocated area must be divided, as a first approximation, by an empirical factor which is within the range of 0.6-0.7 for distillation and 0.45-0.55 for absorption operations. Smaller bubble caps usually require dividing by a larger factor. Also the cross-section thus determined must give enough room for the downcomer and disengaging areas. To test this condition, the tray layout must be

constructed as is the case with any other design method. As for the calculation of the space required by the downcomer areas and their width, see Davies[2] and Bolles;[11] or for a graphical method see the present author's earlier paper.[12]

If the downcomer areas and its width, as well as the cap distance between the weir (s) and the tower walls are suitable, the calculated cross-section together with the selected cap dimensions must be considered from a viewpoint of pressure drop and uniform vapor distribution. This evaluation is brought about in the same way as is done when applying any other design method, and no particulars are given here, since they are described in the technical literature.

To determine the maximum vapor capacity of an existing column, the same initial data are required as with an original design. However, since all tower data are given, fewer empirical considerations and trial and error operations are needed.

First, it must be established whether the cap spacing corresponds to the applied cap dimensions. If the cap spacing is smaller than determined from Equation (10), then Equation (8) will not be satisfied. In order to have a suitable ratio between the annular area developing around the caps and the open slot area, the column cannot be loaded with the same vapor quantity when the cap spacing is smaller than that obtainable from Equation (10). The slots are then not completely open owing to the relatively smaller vapor quantity. For the determination of the open slot height, it is advisable to substitute the actual value of "a" into Equation (26), and to calculate the value of V. Then Calculate a value for V_m using an "a" determined from Equation (10). The open height of the slot may be calculated depending on the slot shape and with knowledge of ratio $\frac{V}{V_m}$ either from Equation (5), (6), or (7), or from the handy diagram given by Bolles.[11]

A = Total allocated area per tray, sq. ft.
A_c = Cap area per tray, sq. ft.
A_L = Downcomer area per tray, sq. ft.
A_R = Riser area per tray, sq. ft.
A_S = Slot area per tray, sq. ft.
A_T = Total cross sectional area, sq. ft.
a = Bubble-cap pitch factor
C = Coefficient in formula for slot velocity
d_c = Cap outside diameter, in.
d_R = Riser inside diameter, in.
F = Factor ($F = u\sqrt{\rho_V}$), lb½/(ft)½ (sec)
G = Gas mass velocity based on total column cross section, lb/(hr) (sq. ft.)
H_S = Slot height, in.
h_s = Slot opening, in.
K = Constant ($K = 1/2\ K_1^2$)
K_1 = Constant ($K_1 = d_R/d_c$)
L = Liquid mass velocity based on total column cross section, lb./(hr) (sq. ft.)
N = Number of bubble caps per tray
u = Vapor velocity based on total column cross section ft./sec.
V = Vapor load, cu. ft./sec
W = Sum of slot width per cap
x = Ratio ($x = W/d_c$)
S_V = Vapor density, lb/cu. ft.
S_L = Liquid density, lb/cu. ft.

Subscripts:
$_m$ = maximum quantity

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Applied Hydrocarbon Thermodynamics

Part 17: K and α Values for Integral Method

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IN PREVIOUS INSTALLMENTS, Parts 14, 15 and 16, the integral method for petroleum fraction vaporization calculations was presented in rigorous and short cut forms, with a series of charts given for the short cut calculations. These calculations all use vapor-liquid K values and relative volatilities. Previous K and values will be improved here by: (a) new nomographs for relative volatility, α, and K_{350}, the vapor-liquid K value for the 350° F. boiling point component and (b) description and illustration of a method for finding K values from the observed TBP curves of the equilibrium vapor and liquid from experimental flash vaporization of a petroleum fraction.

New α and Reference K Charts. The previous α and K_{350} charts (i.e., Figures 15.5 and 15.14) were marked "for illustration purposes only" and included because they had been used in solving examples that were used to demonstate the integral method.

A suitable basis for the preparation of such charts

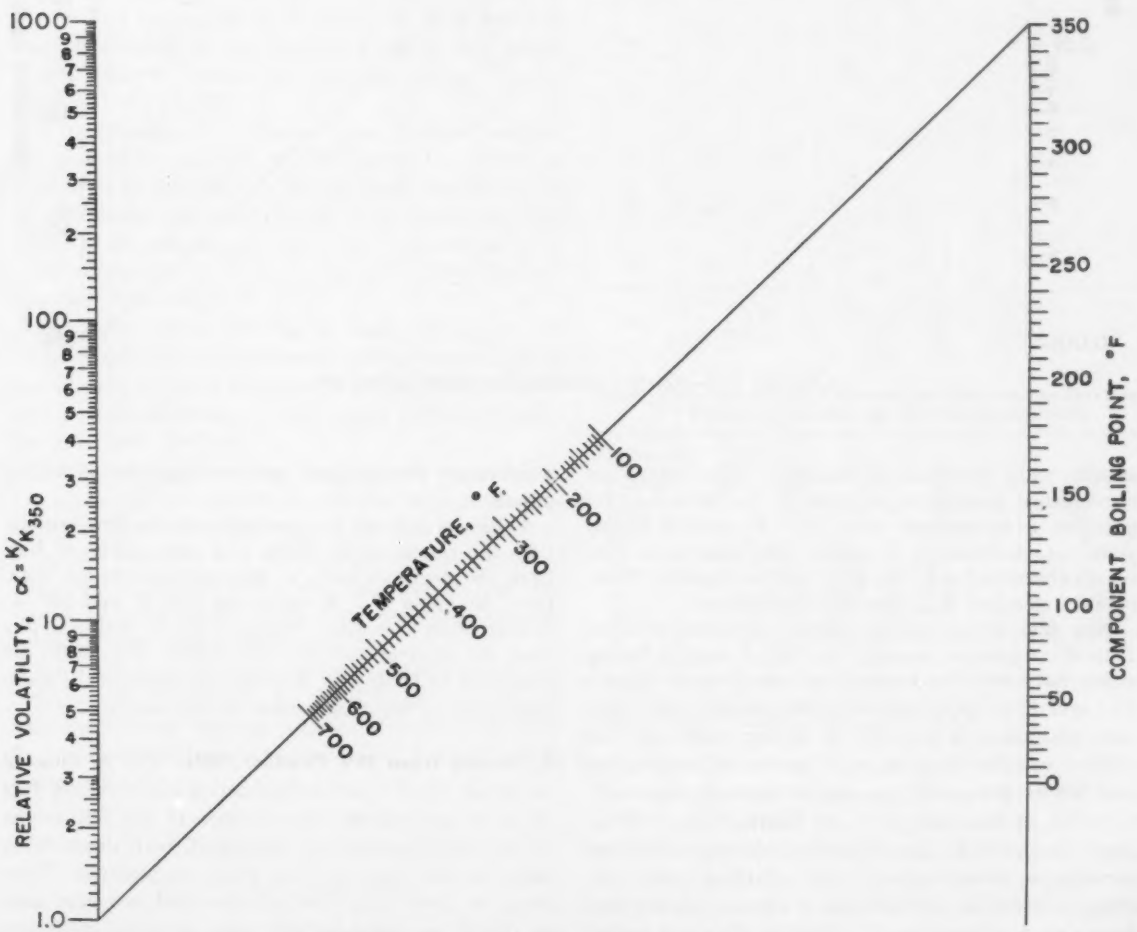

FIGURE 17.1—Relative volatilities for lower boiling cuts.

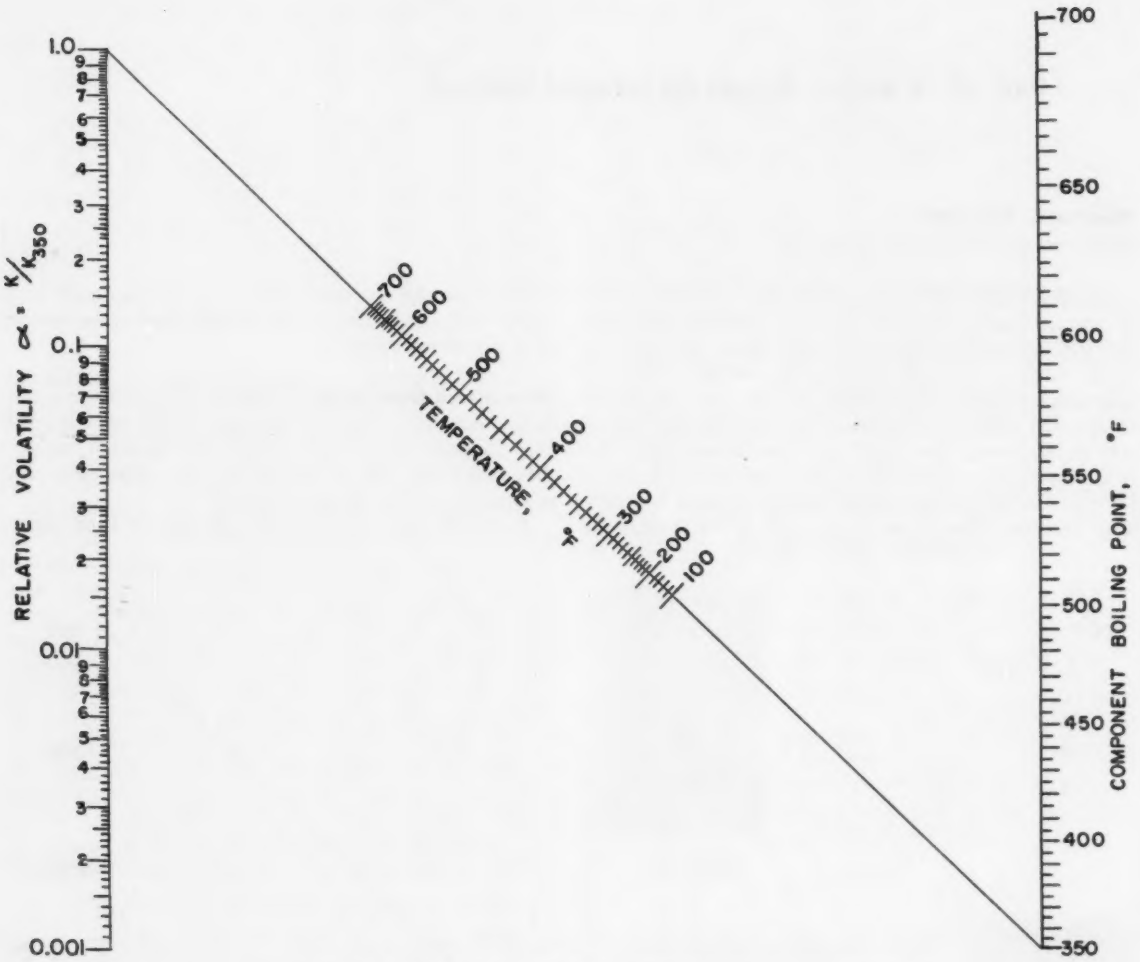

FIGURE 17.2—Relative volatilities for higher boiling cuts.

appears to be the charts of Hinshaw.[1] These charts are convergence pressure type plots of the K values for paraffins from methane to a 750° F. normal boiling point cut. Accordingly, K values were read from Hinshaw's charts and α ($= K/K_{350}$) were computed. Nomographs of α and K_{350} were next constructed.

New nomographs giving relative volatilities of hypothetical components having 0 to 700° F. normal boiling points have been constructed and are given as Figures 17.1 and 17.2. As in the case of Figure 15.5, the reference component is the 350° F. boiling point cut. The relative volatility is given as a function of temperature and boiling point only, i.e., independent of pressure.

Values of K_{350} are given on Figure 17.3, a nomograph that gives K_{350} as a function of temperature and pressure. It would appear that a boiling point scale could be added on the right side of Figure 17.3 and then have a single chart giving K values for the whole boiling point range. This was tried unsuccessfully. The same temperature pressure grid does not apply for all boiling points.

Values of α from the previous and the new correlations are compared in Table 17.1. Also values of K_{350} from the previous and the new correlations are compared in Table 17.2. K values for 150° F. and 550° F. boiling point cuts were estimated at 10 and 100 psia from the previous and new correlations. The results are compared in Table 17.3. For the high boiler at the lower temperatures, the disagreement is very marked.

K Values from EFV Product TBPs. The K value of any small cut of a petroleum fraction was shown in Part 14 to be equal to the ratio of slopes of the TBP curves of the equilibrium vapor and liquid, both slopes being taken at the same boiling point temperature. These slopes or their ratio must be converted to molar units to give K as a mol fraction ratio, its usual definition.

When the TBP curves are smooth and regular, slopes

TABLE 17.1—Comparison of α Values From Previous and New Charts

BP °F.	150		250		450		550	
Chart (Fig.)	15.5	17.1	15.5	17.1	15.5	17.2	15.5	17.2
Temperature °F.								
200	36.0	32.0	7.1	6.0	0.13	0.091	0.0125	0.0064
300	15.5	16.0	4.5	4.2	0.21	0.135	0.038	0.015
400	8.9	8.0	3.3	2.9	0.295	0.225	0.077	0.043
500	5.9	4.6	2.5	2.2	0.38	0.35	0.13	0.11

TABLE 17.2—Comparison of K_{350} Values From Previous and New Charts

Pressure psia	10		30		100	
Chart (Fig.)	15.14	17.3	15.14	17.3	15.14	17.3
Temperature °F.						
200	0.09	0.115	0.036	0.035	0.015	0.0115
300	0.7	0.73	0.26	0.23	0.10	0.074
400	2.4	2.75	0.86	0.90	0.32	0.30
500	5.5	6.8	2.0	2.4	0.72	0.86

can be found and K values evaluated in this way, from the results of equilibrium flash vaporization runs.

Frequently, the TBP curves of the feed and the equilibrium vapor and liquid are plateaus, either faintly or sharply defined. In this case, the TBP slopes cannot be found with sufficient accuracy. The TBP assay curves in Figure 17.4 are examples of very good resolution that may be obtained on raw gasoline fractions. For higher boiling fractions, such as kerosene, the plateaus are less distinct.

A modification of the above "ratio of slopes" method can be used for all kinds of TBP curves, i.e., smooth or plateau or in between. In this modified method "ratios of differences" are used instead. This method is illustrated in the sample calculations in Table 16.6 and the plots in Figures 17.5, 17.6, and 17.7, all for the raw gasoline data shown in Figure 16.14.

As can be seen by referring to Table 17.4 and Figure 17.4, temperature (atmospheric boiling points) points are selected to fall in between the plateaus and the volume percent off points on both vapor and liquid assays are read and tabulated.

These temperature points need not be selected with special care so as to be exactly midway between plateaus or at the inflection points, if any, between the plateaus. It is only necessary that readings be made at the same temperatures for both vapor and liquid curves. Readings should be made on the steep rises connecting the plateaus, for best results, however.

From the liquid volume percent readings (third and fifth columns of Table 17.4), the differences in the volume percentages between adjacent temperatures were found (fourth and sixth columns). The K value is then found from

$$K = \frac{(\Delta \text{ Vol } \%)_{\text{vapor}}}{(\Delta \text{ Vol } \%)_{\text{liquid}}} \frac{(M/G)_{\text{liquid}}}{(M/G)_{\text{vapor}}} \qquad (17.1)$$

where: M/G = moles/gallon

Equation 17.1 gives the y/x ratio for the cut at the mean temperature of the interval. This is the reason

TABLE 17.3—Comparison of K Values From Previous and New Charts

Temperature °F.	150° F. BP				550° F. BP			
	10 psia		100 psia		10 psia		100 psia	
	Prev.	New	Prev.	New	Prev.	New	Prev.	New
200	3.24	3.68	0.414	0.368	0.00112	0.00074	0.00018	.000074
300	10.86	11.70	1.55	1.18	0.0266	0.011	0.0038	0.00111
400	21.4	22.0	2.85	2.4	0.185	0.108	0.0246	0.0129
500	34.2	31.3	4.24	3.98	0.77	0.75	0.93	0.95

TABLE 17.4—Sample Calculations of K Values for Raw Gasoline From TBP's of Equilibrium Vapor and Liquid

Flash Conditions: 300° F, 623 mm Hg, 31.98 volume percent vaporized

Temperature		Vapor Curve 4-Fig. 17.4		Liquid Curve 5-Fig. 17.4		V-L Equilibrium Dist. Ratio	
°F.	1000/°R	Volume Percent On TBP	△ Volume Percent	Volume Percent on TBP	△ Volume Percent	K_{calc}*	log K
180	1.560	16.1	...	1.2	...	.....	.....
...	....	...	10.2	...	1.1	6.73	0.828
200	1.515	26.3	...	2.3	...	.....	.....
...	....	...	10.1	...	1.9	3.87	0.588
220	1.470	36.4	...	4.2	...	.....	.....
...	....	...	5.9	...	1.4	3.07	0.487
235	1.440	42.3	...	5.6	...	.....	.....
...	....	...	15.5	...	3.9	2.89	0.461
250	1.410	57.8	...	9.5	...	.....	.....
...	....	...	10.5	...	4.4	1.74	0.24
280	1.350	68.3	...	13.9	...	.....	.....
...	....	...	6.5	...	3.9	1.21	0.083
300	1.316	74.8	...	17.8	...	.....	.....
...	....	...	6.2	...	4.0	1.127	0.052
320	1.280	81.0	...	21.8	...	.....	.....
...	....	...	3.5	...	3.9	0.654	−0.1845
335	1.260	84.5	...	25.7	...	.....	.....
...	....	...	5.2	...	5.1	0.740	−0.1310
355	1.226	89.7	...	30.8	...	.....	.....

$$^{*}K_{calc} = \frac{(\Delta \text{ Vol. } \%)_{\text{Vapor}}}{(\Delta \text{ Vol. } \%)_{\text{Liquid}}} \frac{(M/G)_{\text{Liquid}}}{(M/G)_{\text{Vapor}}} = \frac{(M/G)_L}{(M/G)_V} = \frac{(M/100G)_L}{(M/100G)_V} = \frac{3.84}{0.728} = 5.28$$

TABLE 17.5—Comparison of K Values for Raw Gasoline Cuts From EFV Data and From Previous and New Nomographs

Flash Condition	300			300			400		
T °F.	1316			623			1434		
P mm Hg	8.77			31.98			52.06		
Vol. % Flashed	2/3			4/5			6/7		
Curves									
BP °F.	A	B	C	A	B	C	A	B	C
200	2.14	2.49	2.15	4.36	4.82	4.44	4.79	5.17	4.8
250	1.097	1.35	1.113	2.37	2.61	2.35	3.02	3.08	2.9
300	0.513	0.66	0.556	1.20	1.28	1.18	1.78	1.73	1.7
350	0.257	0.30	0.265	0.575	0.58	0.560	1.0	0.94	1.0
400	0.123	0.130	0.104	0.257	0.27	0.218	0.536	0.517	0.48
450	0.060	0.064	0.036	0.1097	0.1236	0.076	0.295	0.278	0.22

A—Derived from TBP assays of equilibrium vapor and liquid. (See Figures 17.5, 17.6, and 17.7)
B—Read from previous nomographs, Figures 15.5 and 15.14.
C—Read from new nomographs, Figures 17.1, 17.2, and 17.3.

that the calculated K values in Table 17.4 are entered in the spaces between the temperature entries. Only part of the readings and calculations for this set of EFV data are shown in Table 16.6. The low and high points are omitted for the sake of brevity. The M/100G values are taken from Figure 15.2.

Similar readings and calculations were made for the

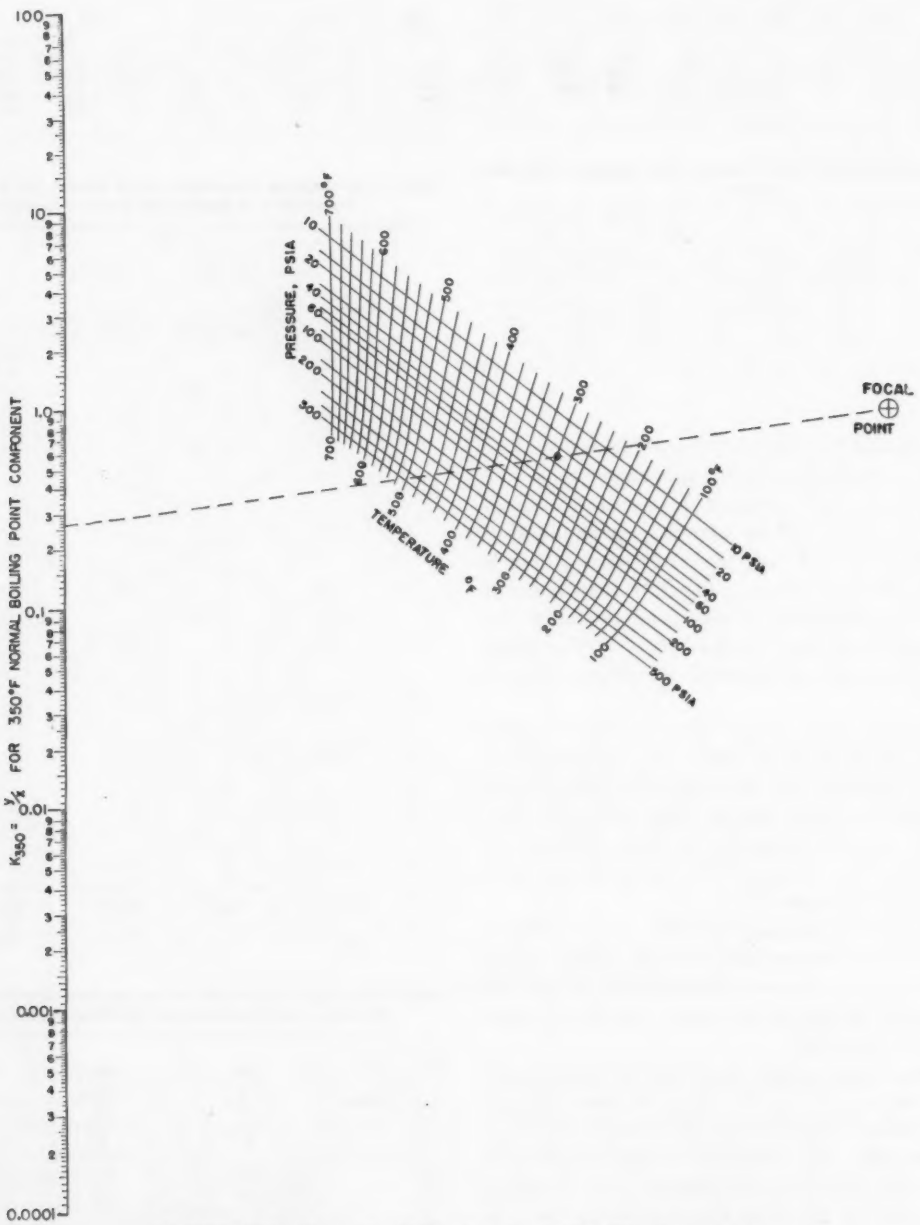

FIGURE 17.3—Vapor-liquid K values for 350° F BP reference cuts.

other two flashes. These are not included. The results for all three sets of EFV data are plotted, however, on Figures 17.5, 17.6, and 17.7.

In plotting these derived K values against temperature, log K vs 1000/BP° R. scales were used. These scales were selected because straight lines were expected from the data on these scales. Another interesting feature of the plots is that the calculated log K values were plotted as chords between the two temperatures defining the intervals involved.

Smooth and regular curves are drawn through these chords in such a way as to balance the areas between the curve and the chords, i.e., the areas above the curve equal the areas below. As can be seen on the plots, the ordinate values of these chords are rather irregular, especially near the ends. This is to be expected because the calculation of the ordinates in these regions involve small differences in numerator or denominator. The TBP data and the plots are not precise enough to expect more precision in the derived K values.

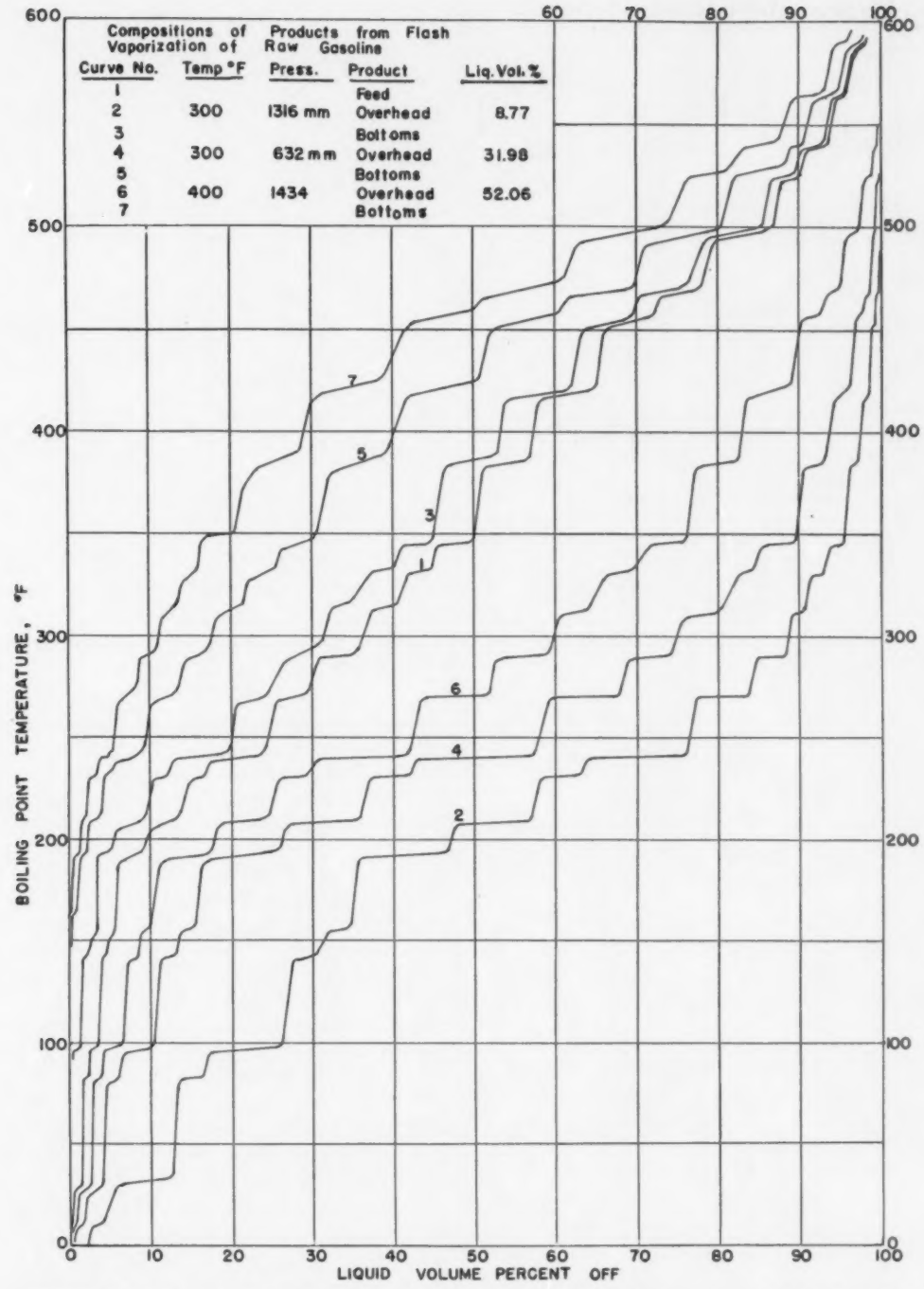

FIGURE 17.4—True boiling point curves of raw gasoline and equilibrium vapor and liquids from flash vaporization. Source: Shell Development Company (Private communication, M. Souders, Jan. 1950).

Comparison of Derived and Chart K Values. From the smooth curves in Figures 17.5, 17.6, and 17.7, K values were found at several intervals of boiling point for this raw gasoline at the pressure and temperature conditions of the flash vaporizations. These K values are given in Table 17.5 along with K values from the previous and the latest nomographs.

It will be noted that the new nomographs are in good agreement with these derived Ks at the lower and intermediate boiling points. For the higher boiling points, the new nomographs get K values that are lower than the derived values while the old charts give Ks that are higher at 300° and lower at 400° than the values found from the TBP curves of the equilibrium vapor and liquid from flashing the raw gasoline.

These results emphasize the need for more research

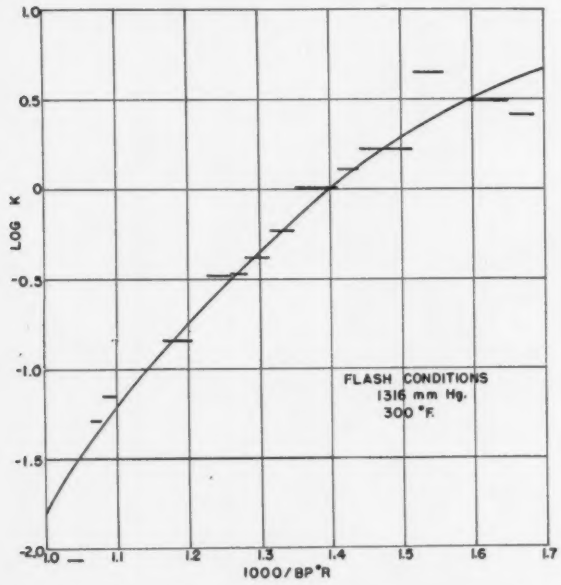

FIGURE 17.5—Derived K values from TBP curves 2 and 3 of Figure 17.4.

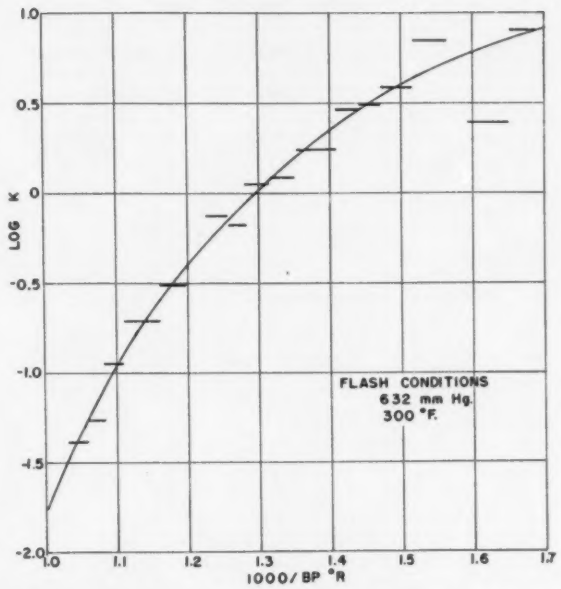

FIGURE 17.6—Derived K values from TBP curves 4 and 5 of Figure 17.4.

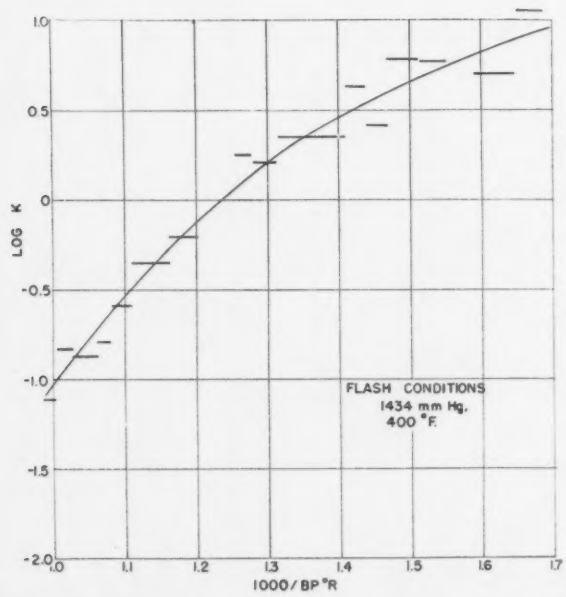

FIGURE 17.7—Derived K values from TBP curves 6 and 7 of Figure 17.4.

along these lines to obtain improved vapor-liquid equilibrium distribution ratios, i.e., K values for applying this integral method.

Recommended Investigations. Experimental EFV runs should be made on selected petroleum fractions to obtain data for deriving K values of the infinitesimal cuts of petroleum by the method illustrated above.

Recirculating equilibrium stills of the Othmer[2,3] type are recommended rather than the once-through flash type stills recently proposed.[4,5] Equilibrium attainment is more certain in the recirculating still. Equilibrium attainment is more uncertain for the wide boiling mixtures than for the narrow or close boiling mixtures. Both wide and narrow mixtures should be run in order to find the effects of composition.

Samples of the equilibrium vapor and liquid should be taken for analysis. This analysis should include TBP assays and density vs boiling point determinations. Any other inspection data that might help to characterize the TBP cuts would also be of value.

Data should be taken on the same material at more than one pressure. For light oils, atmospheric and higher pressures should be used. For middle oils, atmospheric pressure and vacuum conditions should be used in the equilibrium vaporization. For heavy oils, vacuum conditions may have to suffice because of temperature limitations caused by cracking.

Working plots should be made of the TBP curves for the equilibrium vapors and liquids and of the gravities and molecular weights. From these plots, the K values can be found, as illustarted.

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Use These Ks in Hydrofining

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In recent years there has been an increase in petroleum refining operations using excess hydrogen at moderate pressures. Design calculations for separation of hydrocarbons from hydrogen require equilibrium data on the solubility of hydrocarbons in compressed hydrogen; this work reports K values for hydrocarbons in the C_4 to C_{10} range in contact with hydrogen at pressures up to 2500 psia.

THE K VALUE for a component is given by the rigorous thermodynamic equation

$$K_1 = \frac{y_1}{x_1} = \frac{\gamma_1 f_1^L}{\phi_1 P} \qquad (1)$$

where γ_1 = liquid-phase activity coefficient of component 1
f_1^L = fugacity of pure liquid 1 at the temperature and pressure of the solution
ϕ_1 = vapor-phase fugacity coefficient of component 1
P = total pressure
y_1 = mole fraction of component 1 in the vapor phase
x_1 = mole fraction of component 1 in the liquid phase

Let component 1 be a hydrocarbon in contact with hydrogen at moderate pressures and at a temperature well below the critical of the hydrocarbon. Under these conditions there is little hydrogen in the liquid phase and thus $\gamma_1 = 1$. The vapor phase fugacity coefficient is given by an expression based on the virial equation of state terminated after the second virial coefficient:[7]

$$\ln \phi_1 = \frac{2}{v}(y_1 B_{11} + y_2 B_{12}) - \ln Z \qquad (2)$$

where v = molar volume of the vapor-phase mixture
y_2 = mole fraction of hydrogen in the vapor phase
B_{11} = second virial coefficient of pure 1, characteristic of the 1-1 interaction
B_{12} = second virial coefficient characteristic of the 1-2 interaction
Z = compressibility factor of the vapor-phase mixture

The compressibility factor and the molar volume are related to the virial coefficients by

$$Z = \frac{Pv}{RT} = 1 + \frac{P}{RT}(y_1^2 B_{11} + 2y_1 y_2 B_{12} + y_2^2 B_{22}) \qquad (3)$$

where B_{22} = second virial coefficient of pure hydrogen, characteristic of the 2-2 interaction.

The liquid-phase fugacity of pure 1 is given by

$$f_1^L = P_1^o \exp\frac{B_{11} P_1^o}{RT} \exp\frac{v_1^L (P - P_1^o)}{RT} \qquad (4)$$

where P_1^o = vapor pressure of component 1 at temperature T
v_1^L = molar liquid volume of component 1 at temperature T

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Values of y_1 are found from the equilibrium equations:

$$(1 - x_2) f_1^L = \phi_1 y_1 P \qquad (5)$$

$$(1 - y_1) f_2^V = H x_2 \qquad (6)$$

where f_2^V is the fugacity of pure hydrogen gas given by

$$f_2^V = P \exp\frac{B_{22} P}{RT} \qquad (7)$$

H is a Henry's law constant for hydrogen taken from the correlation of Hildebrand and Jolley.[2]

Values of B_{11} can be computed with high accuracy from the equation of Pitzer and Curl[6] and B_{22} can readily be computed from the volumetric data of hydrogen.[3] Vapor pressures and liquid molar volumes for hydrocarbons are readily available. Hence the only other required data are values of B_{12}. A correlation for B_{12} for mixtures of hydrogen and nonpolar substances has recently been presented;[9] it was shown that reliable values of B_{12} could be computed from the ionization potential, polarizability, acentric factor and critical volume of the hydrocarbon. Values obtained from this correlation were used in this work to compute K values for seventeen hydrocarbons for the pressure range 500-2,500 psia.

Calculations. The calculations were performed with an IBM 701 electronic digital computer. Input data and calculated results were stored and used as floating point numbers containing 8 digit positions. Floating point calculations were carried out using a stored floating point program.

It was necessary to use a trial-and-error process in solving Equations (5) and (6). For a given temperature and pressure a value of y_1 is assumed. This allows calculation of x_2 from Equation (6), and this value can be used in Equation (5) to solve for y_1. The assumed and calculated values of y_1 are compared and a two-point extrapolation process was used until the following convergence condition was met:

$$|(y_1)_{calc} - (y_1)_{assumed}| \leq (\varepsilon y_1)$$

where (εy_1) is the desired error limit.

Convergence is quite rapid using this scheme and it was found that less than 1 second was required per pair of temperature and pressure values. In this work $\varepsilon y_1 = 10^{-3}$.

Results. K values for seventeen hydrocarbons are plotted in Figures 1-17. Results are given for paraffinic hydrocarbons from C_4 to C_{10}, for cyclohexane, and for benzene, toluene and three xylenes.

The K values shown in Figures 1-17 are considerably lower than those found in conventional K charts. This is due to the fact that a hydrocarbon's solubility in compressed hydrogen is smaller than its solubility in heavier compressed gases such as nitrogen, methane, ethane, and others.[8]

Since experimental K data are scarce for hydrocarbons above C_4 in the presence of hydrogen no exhaus-

Use These Ks in Hydrofining . . .

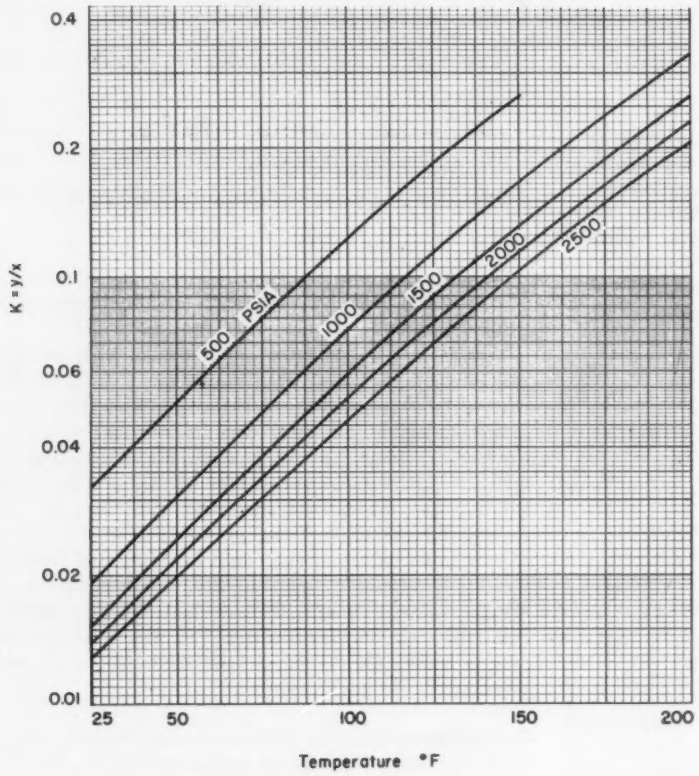

FIGURE 1—K values for n-Butane.

tive comparison between calculated and experimental results can be made. However, in view of the good reliability of the correlation used for obtaining the second virial coefficient B_{12} it is believed that the calculated results are good to within ten percent or better, especially at the higher temperatures. At low temperatures it is difficult experimentally to obtain reliable K values for hydrocarbons of low volatility; disagreement between computed and observed K values at lower temperatures may, in many cases, be due to experimental inaccuracies. A brief comparison of calculated and observed K values for hexane and decane is shown in Table 1.

ACKNOWLEDGMENT

The authors are grateful to William Wang for his extensive assistance in performing the calculations, and to the University of California Computing Center for permission to use their IBM 701 computer. This work is based on research studies supported by the Petroleum Research Fund of The American Chemical Society. The authors are grateful to the donors of this fund.

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TABLE 1—Comparison of Calculated and Observed K Values

Temperature °F	Pressure psia	K Calculated	K Observed (1)
	n-Butane		
25	500	0.0321	0.0350
	1000	0.0192	0.0219
	1500	0.0154	0.0170
50	500	0.0505	0.0538
	1500	0.0244	0.0270
	2500	0.0200	0.0213
100	500	0.122	0.125
	1000	0.0740	0.0770
	1500	0.0585	0.0619
200	1000	0.330	0.325
	1500	0.264	0.269
	n-Hexane		**Observed (5)**
220	500	0.0920	0.0996
	1000	0.0557	0.0581
	1500	0.0410	0.0445
	2000	0.0369	0.0392
	2500	0.0335	0.0369
340	500	0.459	0.409
	1000	0.281	0.250
	1500	0.221	0.201
	2000	0.197	0.180
	2500	0.179	0.171
	n-Decane		**Observed (4)**
104	588	0.00018	0.00019
176	588	0.0012	0.0014

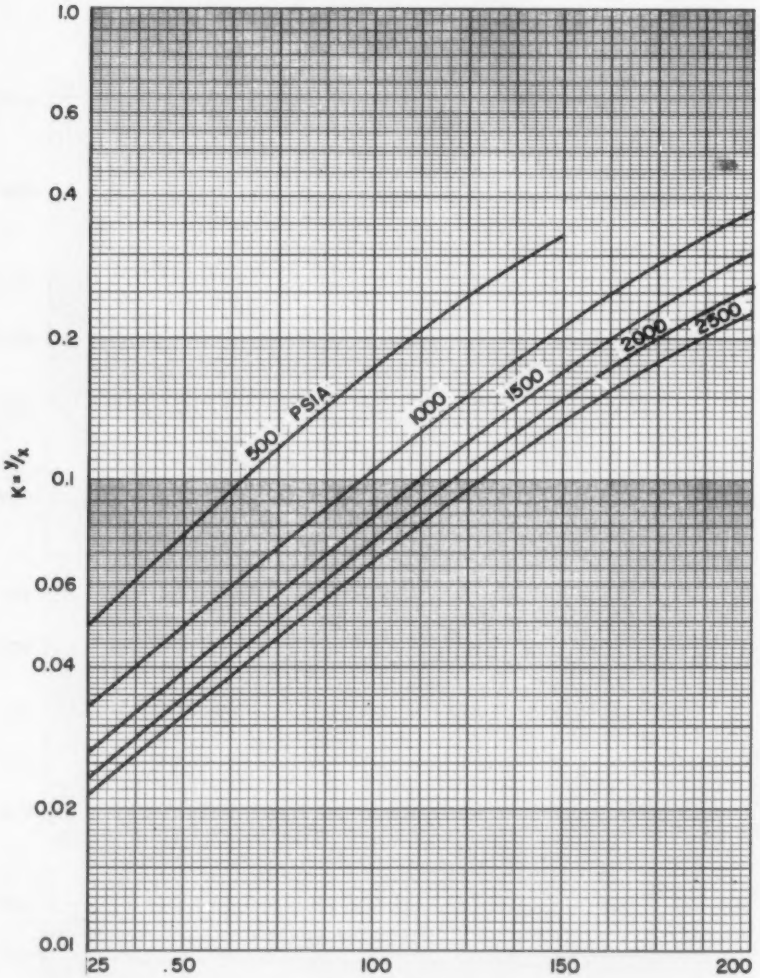

FIGURE 2—K values for Isobutane.

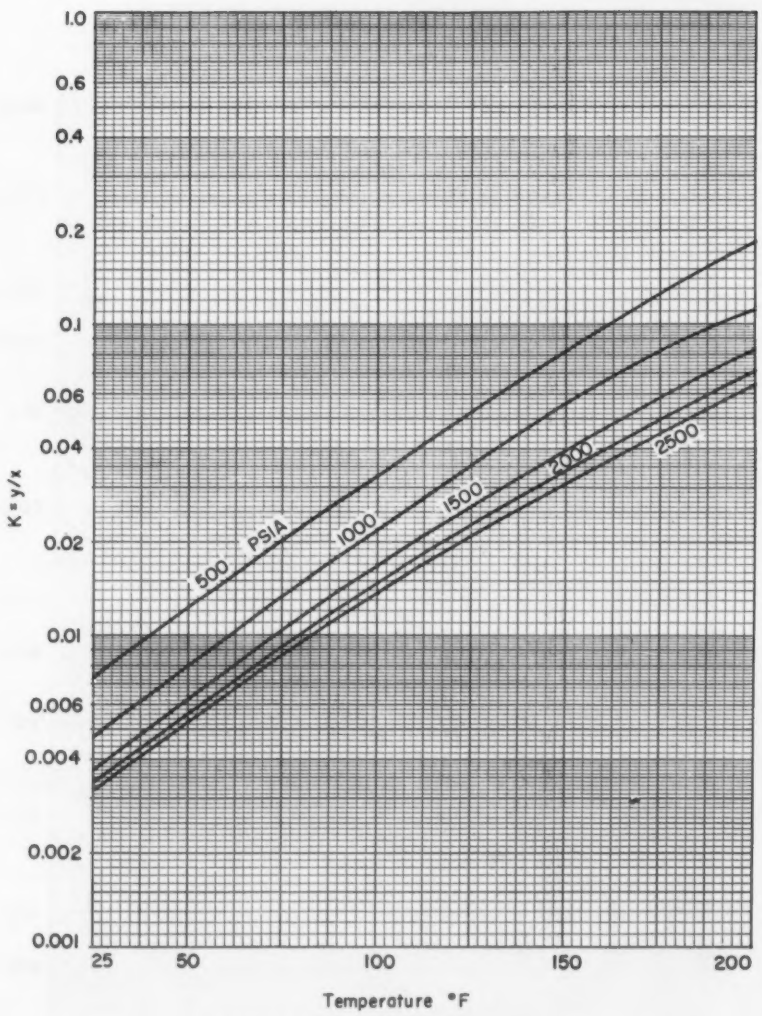

FIGURE 3—K values for n-Pentane.

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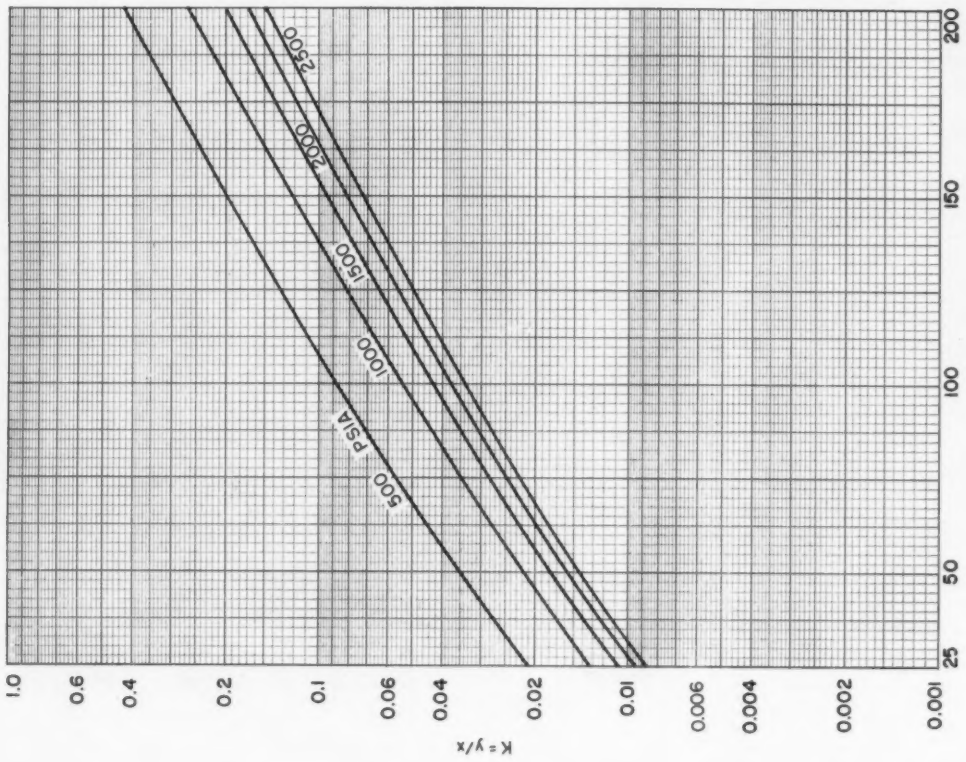

FIGURE 5—K values for Neo-pentane.

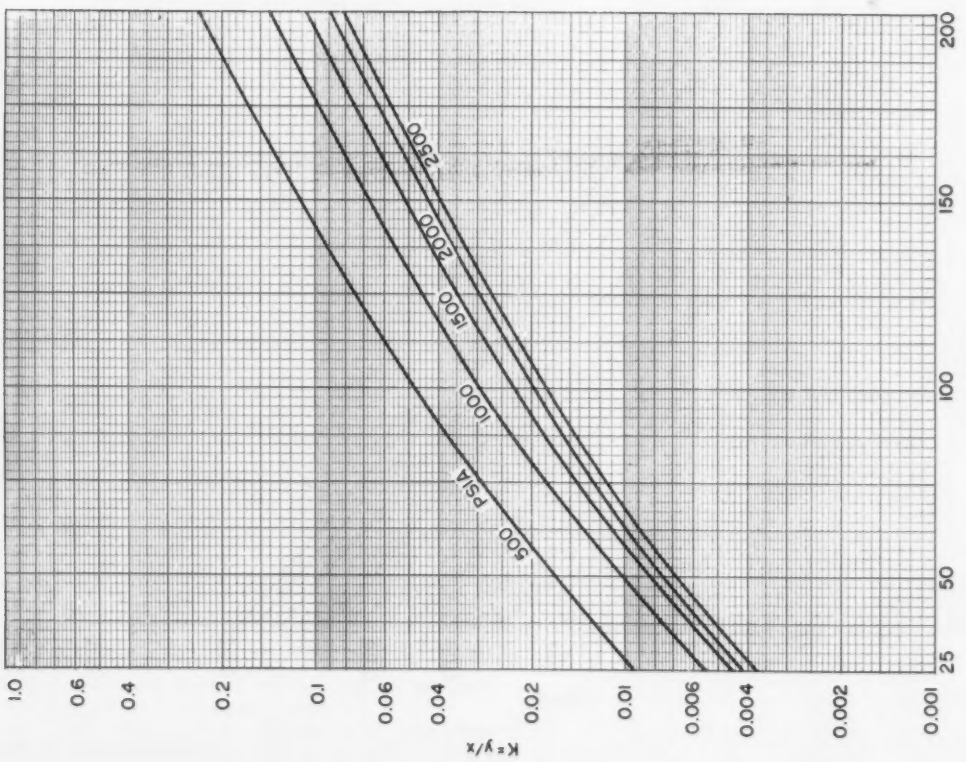

FIGURE 4—K values for Iso-pentane.

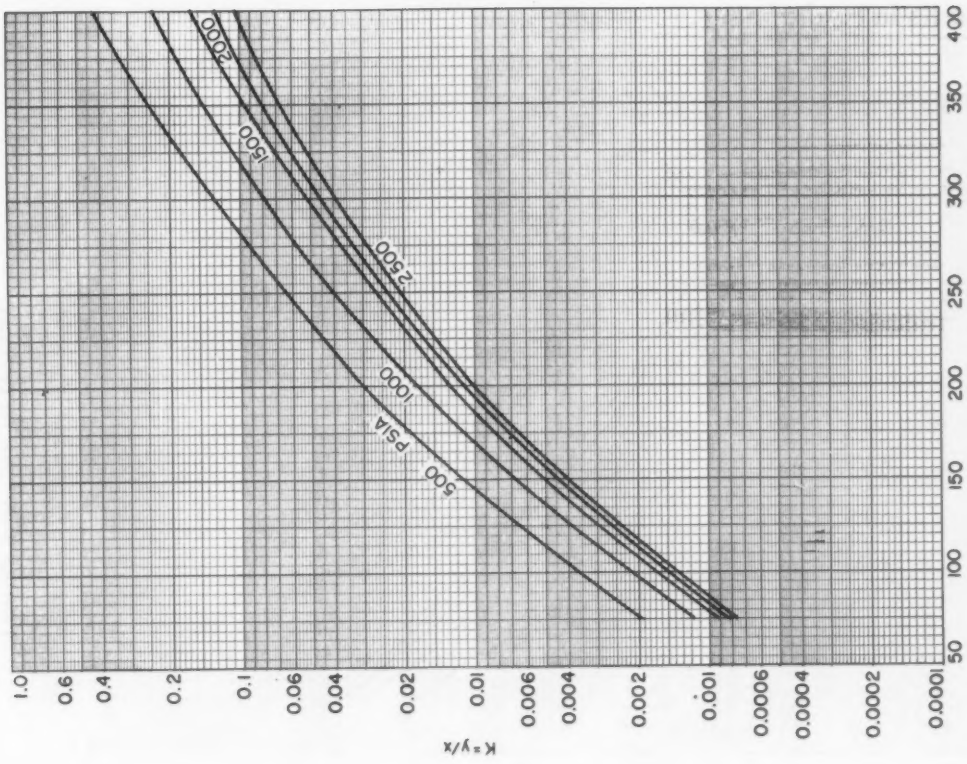

FIGURE 7—K values for n-Heptane.

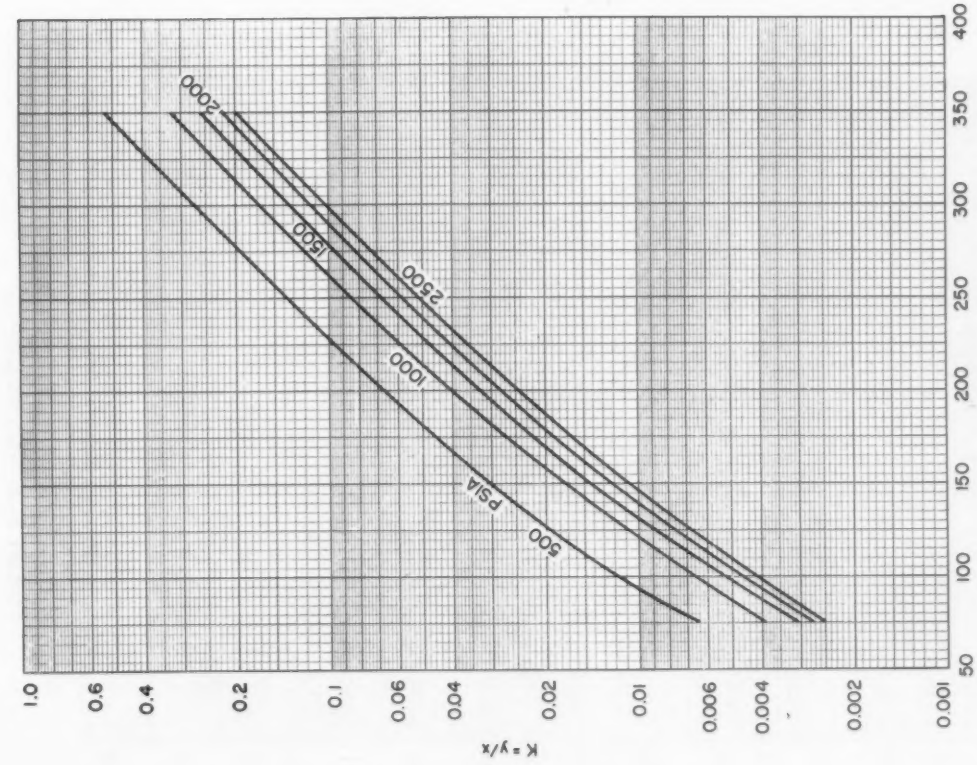

FIGURE 6—K values for n-Hexane.

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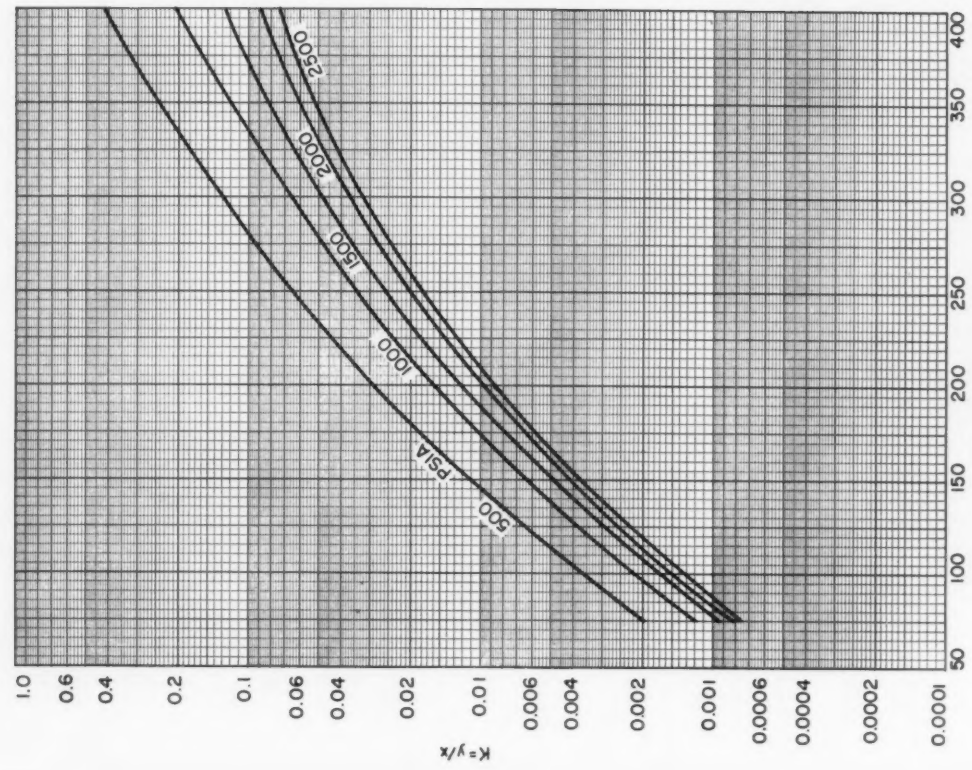

FIGURE 9—K values for Iso-octane.

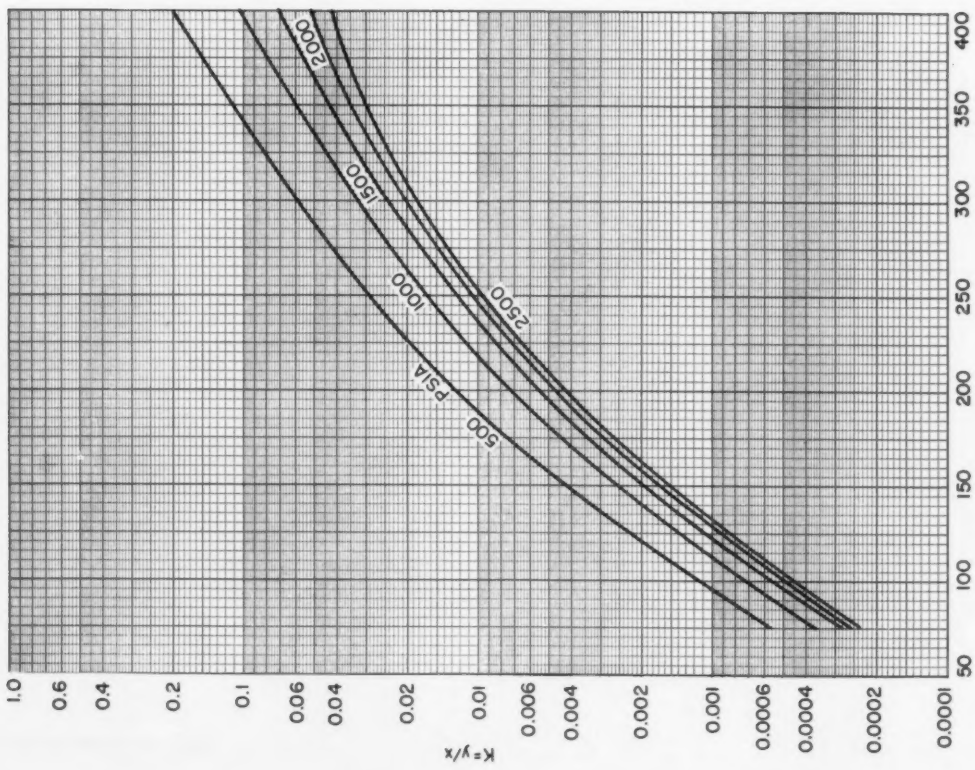

FIGURE 8—K values for n-Octane.

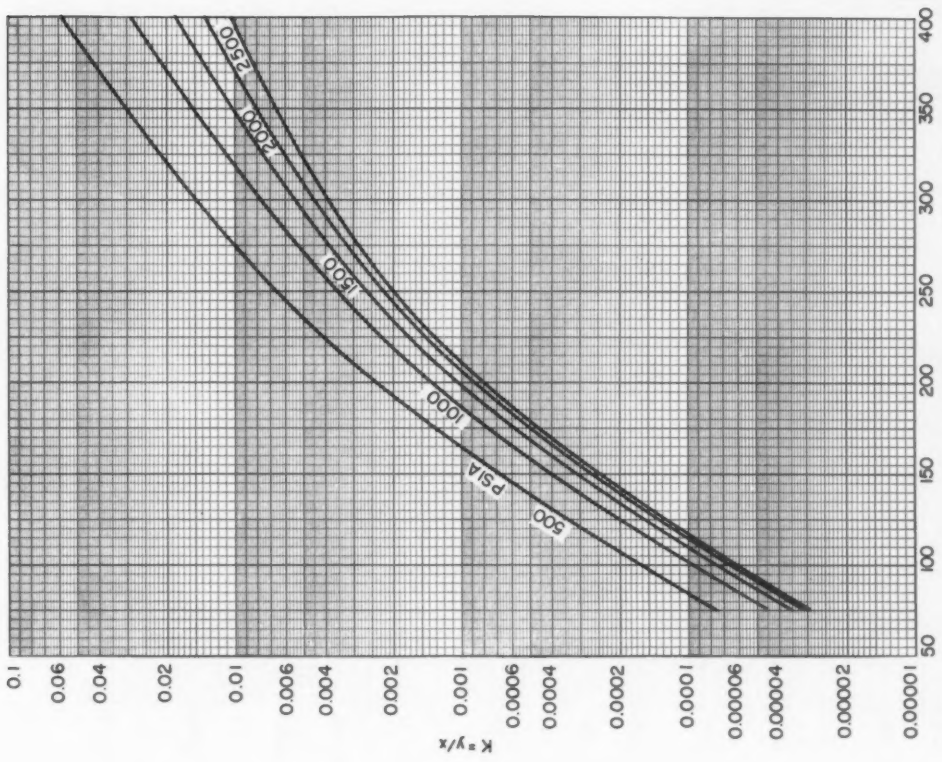

FIGURE 11—K values for n-Decane.

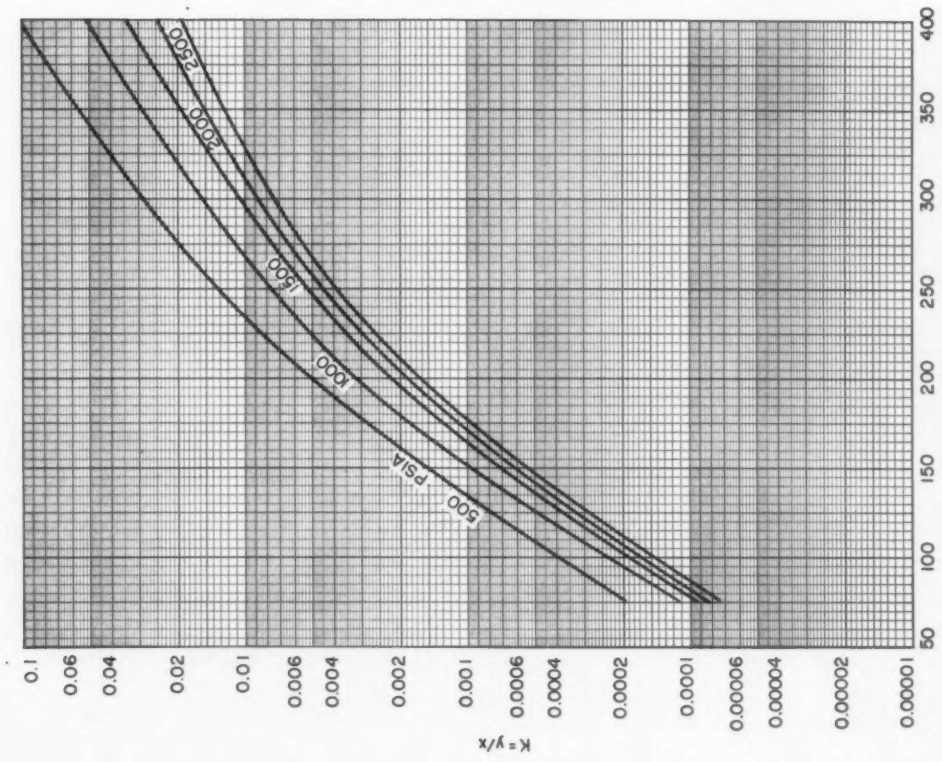

FIGURE 10—K values for h-Nonane.

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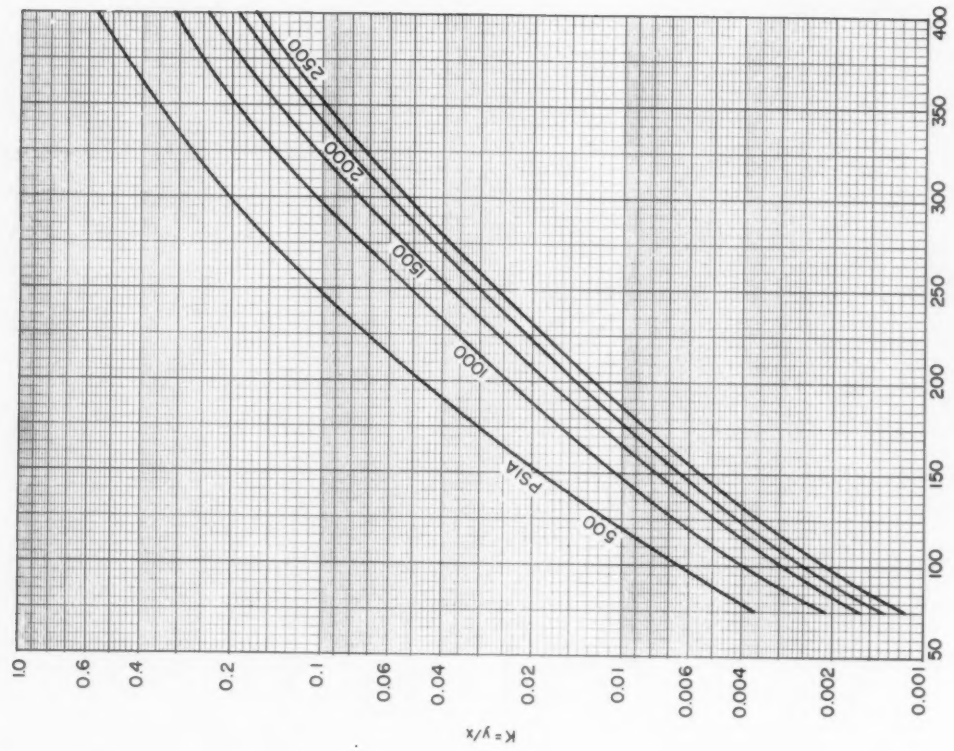

FIGURE 13—K values for Benzene.

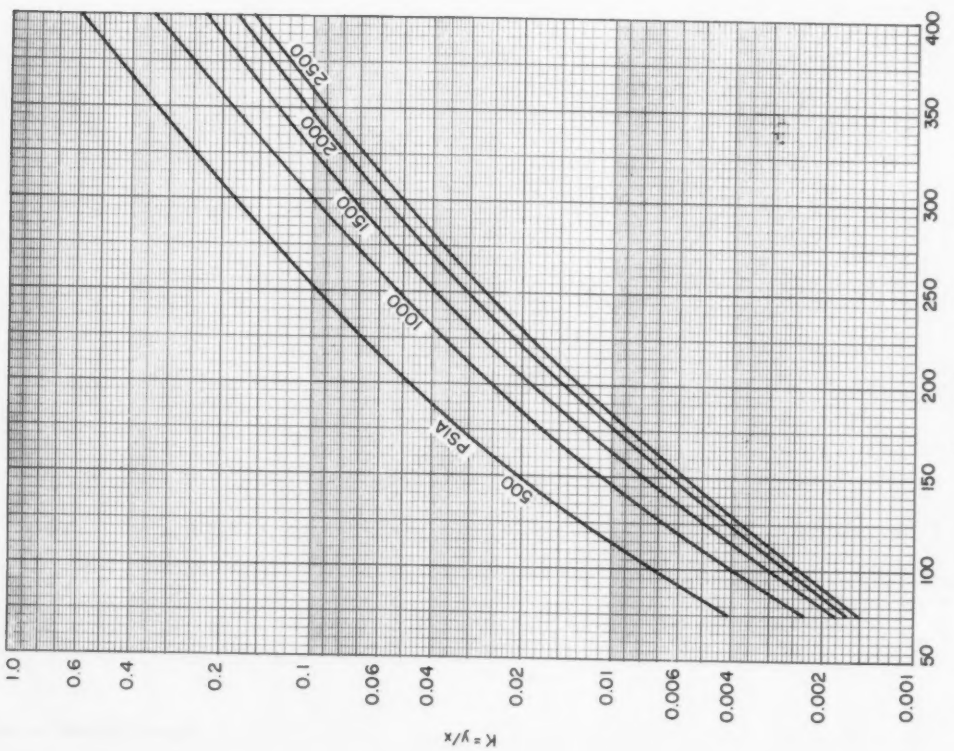

FIGURE 12—K Values for Cyclohexane.

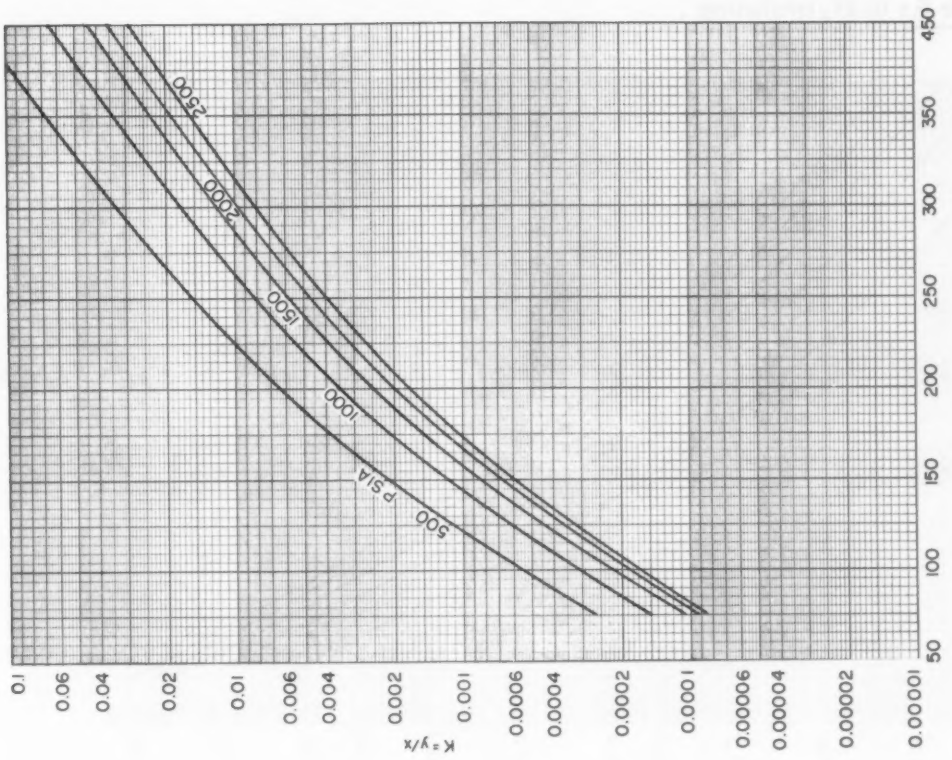

FIGURE 15—K values for o-Xylene.

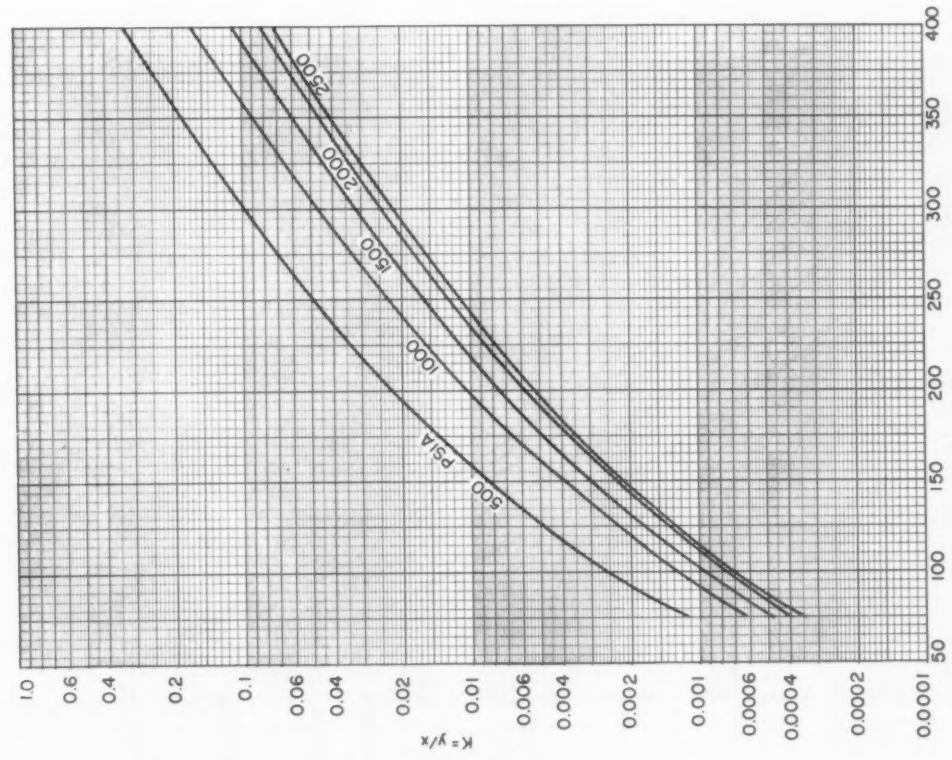

FIGURE 14—K values for Toluene.

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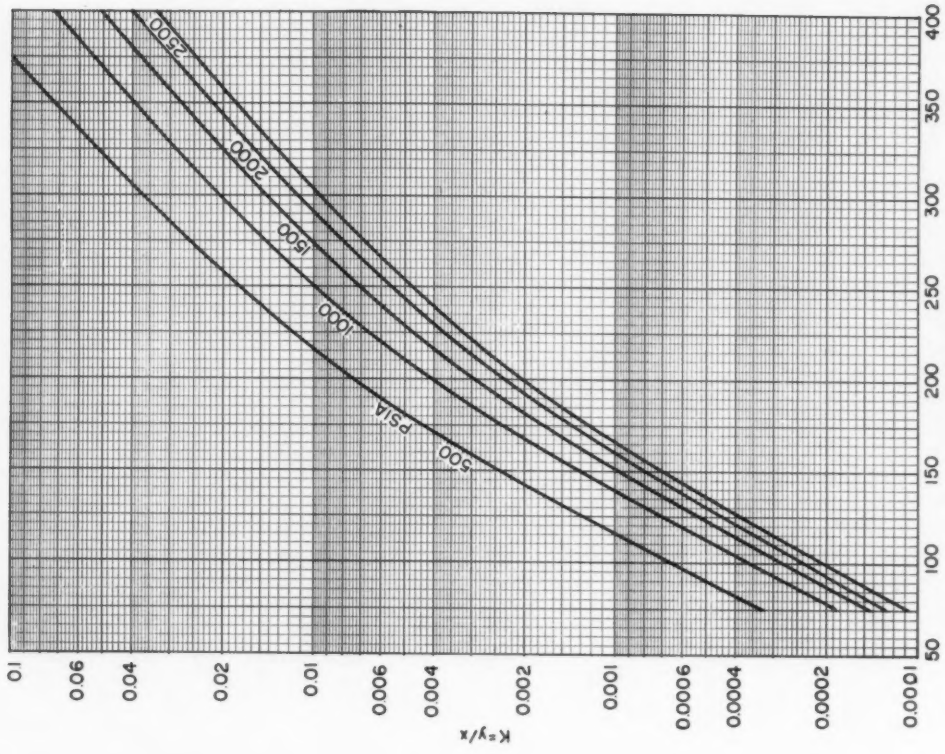

FIGURE 17—K values for m-Xylene.

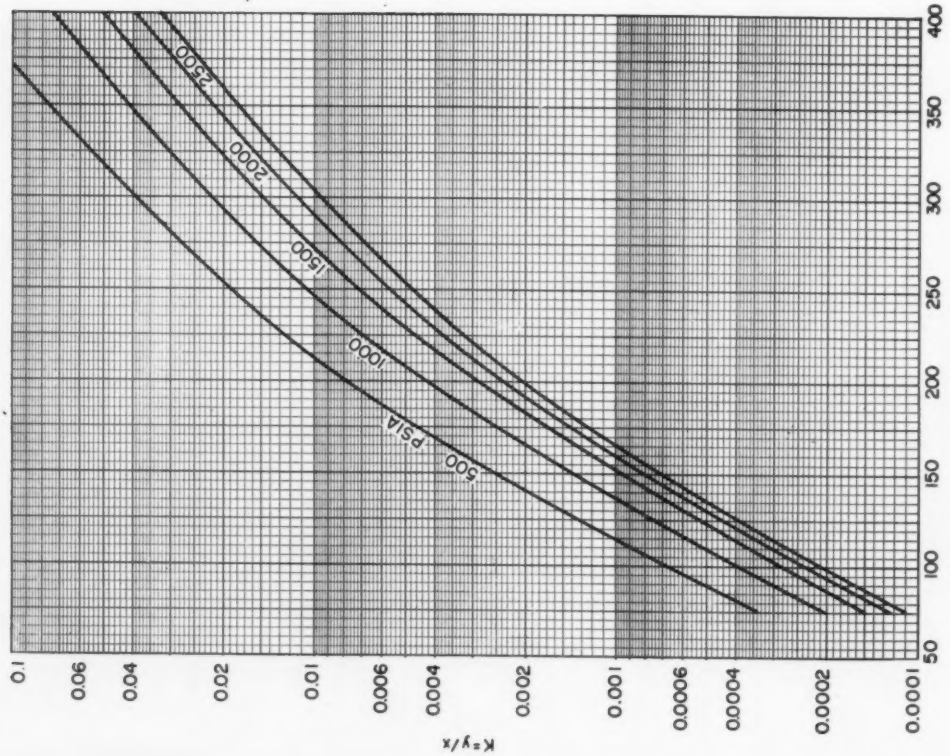

FIGURE 16—K values for p-Xylene.

How to Check Costs When Selecting Material for Heat Exchangers

It is the exception today when the lowest cost material for your exchanger proves to be the most economical choice

E. N. Sieder, Alco Products, Inc., Houston
G. H. Elliott, Alco Products, Inc., Dunkirk, N. Y.

TODAY, the design engineer can choose from a wealth of alloys to meet the challenge of high temperatures and corrosive fluids. However, the wide availability of alloys makes the economical choice a difficult one.

By applying the following simple set of rules, charts and tables, the engineer can determine rapidly the comparative effect on cost of the alloys generally used in heat exchangers. The more common alloys for heat exchangers are shown in Table 1.

The nonferrous alloys, admiralty for tubes and naval rolled brass for tube sheets and baffles, are in such wide use in heat exchangers that their advantages will not be discussed, except in the tables and charts dealing in cost comparisons.

Chrome And Chrome Moly Alloys. The straight chrome alloys, 1¼ chrome ½ moly, 4-6 chrome and 11-13 chrome, are widely used in heat exchangers and find favor because of their resistance to corrosion and good high-temperature characteristics.

The chrome moly alloys are also in demand for services where hydrogen penetration and accompanying intergranular cracking is a problem. The table below gives recommended maximum metal temperatures for which certain grades of steel and chrome alloys should be used in this type of service.

	Below 450° F.[1]	450°-550° F	Above 550° F
For H_2-HC streams where H_2S quantity is below 0.2 mol. percent	Steel ASTM A-201 Grade A or B	0.5% Mo. Steel	1% cr-0.5% Mo.
For H_2-HC streams where H_2S is present in quantity above 0.2 mol. percent	Steel	0.5% Mo. Steel	4-6% cr. 0.%5 Mo.[2]

[1] Maximum metal temperatures.
[2] Aluminized low chrome alloys may be preferable.

One-half chrome ½ moly may be used for temperatures up to 1,000° F where corrosion is not a factor. It is often employed as a base material for more expensive cladding for shells, tube sheets and covers. It is readily welded to carbon steel, requiring only a mild preheat for best results.

Ferritic chromium steels have increasingly high air hardening characteristics as the chromium content is increased up to approximately 7 percent. The tendency for air hardening then decreases with further chrome additions, and steels having more than about 13 percent chrome show little or no tendency to air harden. Carbon content, of course, also increases the hardening characteristics. To prevent the formation of brittle Martensite as a result of

	Carbon Steel	Carbon Mo Steel	3 1/2 Nickel Steel	Cr-Cu-Nickel Steel	1/2 Cr-1/2 Mo	2 1/4 Cr-1/2 Mo	Type 304	Type 316	Type 347	Type 321	4-6 Cr 1/2 Mo	12 Cr TP 410	17 Cr TP 430	70-30 Cu-nickel	Silicon Bronze	monel
Carbon Steel	S															
Carbon Mo Steel	S	S														
3 1/2 Nickel Steel	S	S	S													
Cr-cu-nickel Steel	S	S	S	S												
1/2 Cr-1/2 Mo	S	S	S	S	S											
2 1/4 Cr-1/2 Mo	S	S	S	T	S	S										
Type 304	S	S	S	S	S	S	S									
Type 316	S	T	T	T	T	T	S	S								
Type 347	S	T	S	S	S	T	S	S	S							
Type 321	S	S	S	S	S	T	S	S	S	S						
4-6 Cr 1/2 Mo	T	T	T	T	T	T	T	T	T	T	T					
12 Cr TP 410	S	S	T	T	S	S	T	T	T	T	T	S				
17 Cr TP 430	T	T	X	X	T	T	T	T	T	T	T	T	T			
70-30 Cu-nickel	T	T	X	X	X	X	X	X	X	X	X	X	X	S		
Silicon Bronze	T	T	T	X	X	X	X	X	X	X	X	X	X	T	S	
monel	T	T	T	T	T	X	T	T	T	T	T	X	X	S	T	S

Legend: S = Satisfactory welds may be made with standard good shop practice. Preheating and/or stress-relieving may be necessary.

T = Special technique required. This includes heat treatment of a special nature or the use of special types and alloys of welding electrodes. Specific welding processes may also be necessary.

X = No data available or known to be unsatisfactory.

METALS AND ALLOYS WITH SATISFACTORY WELDABILITY

The materials in the following groups require no preheat in normal plate thicknesses:

CARBON STEEL: SA-285, SA-201, SA-216, SA-181, SA-105, SA-106.

STAINLESS STEELS: Types 304, 308, 309, 310, 316, 317, 321, 347.

COPPER AND ALLOYS: Pure Copper, Silicon Bronze, Aluminum Bronze, 70-30 Copper-Nickel.

OTHER: Nickel, Aluminum, Monel.

For the following materials, preheat is generally desirable over ½ in. thickness:

LOW ALLOY STEELS: A-212 Carbon Steel, C--Mo Steels, ½ Cr-½ Mo. Steel, Cr-Cu-Ni Steel, 3½ Nickel Steel.

METALS AND ALLOYS REQUIRING SPECIAL WELDING TECHNIQUE

Air-hardenable alloys which require preheat temperature:

CHROME STEELS: Type 502 (4-6 Cr-½ Mo); Type 410 (12 percent Cr), 2¼ Cr-½ Mo.

FIGURE 1—Weldability of similar and dissimilar alloys.

welding, all the chromium steels are preheated during the welding process, and, in the 5 percent chrome range, this preheating may be as high as 600° F. If the sections are extremely heavy or sections of unequal thickness are being welded, it is advisable to stress relieve at 1,100 or 1,300° F. Extra precautions during inspection are advisable to insure that no cracks are present for welds involving these alloys.

In order to roll or form 4-6 and 11-13 chrome alloys in thicknesses 1 inch and over, it is generally necessary to preheat them to a temperature of 1850° F to 1,900° F.

As a tube material, 4-6 percent chrome finds wide favor. Satisfactory expanding characteristics are obtained by proper heat treatment and, with care, tubes of 12 gage or lighter can be expanded into carbon steel tube sheets. Tubes of 11-13 chrome are available, but must be used with tube sheets having a higher hardness than is obtainable in carbon steel.

Stainless Steels. The design engineer should avoid situations where large sections of 18-8 stainless must be welded to carbon steel or low chrome alloys as the large difference in the expansion coefficients of the two materials will cause high stresses which may cause failure at or near the weld. Even if a successful weld is made, differential expansion brought about by high service temperatures may cause high local stresses and eventual failure. Attachments of relatively small pieces of stainless teel such as an 18-8 nozzle to carbon steel or low alloy shells are generally satisfactory, however.

When an 18-8 stainless vessel or heat exchanger requires heat treatment at temperatures of 1,550° or above, it is undesirable for any of the components to be of steel because the high temperature of the heat treatment and subsequent water quenching would badly distort the assembly and may cause the carbon steel to crack because of an unfavorable metallurgical structure and excessive hardening.

Although the 18-8 stainless steels may show high ultimate strengths, designers must be careful not to exceed the rather low yield point (approximately 30,000 psi) of these materials during hydrostatic test conditions. This is particularly important in the case of flanges and covers which may be permanently sprung, and stud bolts elongated, by overtightening a joint under hydrostatic test.

Figure 1, Weldability of Alloy Combinations, should be helpful to the engineer facing the problem of selecting corrosion resisting materials for a heat exchanger.

Alloy Cladding. The use of alloy-clad steels offers wide possibilities for economies and ease of fabrication. For heavy vessel and shell wrapper plates where corrosion is a factor and temperatures moderate, stainless cladding on a carbon steel base material will show appreciable savings. Where high temperatures and corrosion are both factors, 18-8 alloy

TABLE 1—Alloy Materials Chart

ASTM Spec.	Alloy	Coefficient of Expansion at 500° F	Maximum Allowable Stress 300° F	800° F	1000° F	1100° F	Approx. Cost $ Per Pound
SA-212-B	Carbon-Silicon Qty 10,000 lbs.	7.23x10-6	17,500	12,000	2,500	.....	.095
SA-387-A	½ Cr-½ Mo. Qty. 2000-4000 lbs.	7.23x10-6	16,250	15,650	6,250	.....	.165
SA-387-C	1¼ Cr-½ Mo. Qty. 2000-4000 lbs.	7.0 x10-6	15,000	15,000	7,800	4,000	.169
SA-357	4-6 Cr-½ Mo. Qty. 3000-6000 lbs.	6.75x10-6	15,000	12,800	7,300	3,300	.535
A-240-B TP 410	11-13 Cr Qty. 3000-6000 lbs.	6.13x10-6	15,100	12,750	6,400	2,900	.55
B-17	Naval Rolled Bronze Tube Sheets Qty. 500-1000 lbs.	11.8 x10-6	10,500	.....	.....	.....	.761
A-167-3 TP 304	18 Cr-8 Nickel Qty. 3000-6000 lbs.	9.75x10-6	16,000	14,550	12,500	7,500	.708
A-167-6 TP 347	18 Cr-8 Nickel Qty. 3000-6000 lbs.	9.75x10-6	17,000	14,550	13,500	12,500	.898
B-127	monel Qty. 2000-5000 lbs.	8.45x10-6	17,000	14,500	.....	.....	1.23

Information presented in this table is not intended for use by the heat exchanger design engineer in preparing finalized designs, but presents for comparison purposes certain information useful when selecting the proper material for an alloy heat exchanger.

Ultimate tensiles shown are four times maximum allowable stress from the 1952 ASME Code.

Coefficients of expansion were taken from several sources and represent the average coefficient from room temperature to 500° F. The ASTM Spec. No. and cost figures are for plate forms as might be used for shells, with the exception of naval rolled brass where the information pertains to tube sheets.

TABLE 2—Extra for Alloy Construction in Percent of Steel Base Price, 150 lb. Working Pressure.

	SHELL DIAMETERS 12	14	16	18	20	22	24	27	30	33	36	39	42
All Steel Heat Exchanger	100	100	100	100	100	100	100	100	100	100	100	100	100
Naval Rolled Tube Sheets & Baffles	13	15	18	20	21	21	21	21	21	21	21	22	22
Monel Tube Sheets & Baffles	23	31	34	36	37	38	39	39	39	39	39	38	38
1¼ Cr-½ Moly Tube Sheets & Baffles	6	6	7	7	7	8	8	8	9	9	9	9	9
4-6 Percent Cr-½ Moly Tube Sheets & Baffles	19	22	24	25	26	26	26	25	25	25	24	24	24
11/13 Cr Tube Sheets & Baffles	21	23	25	26	27	27	27	27	26	26	26	26	26
304 Stainless Tube Sheets & Baffles	22	26	28	30	30	31	31	31	30	30	29	29	29
Monel Shell & Cover	42	46	49	51	52	52	51	49	47	44	41	39	38
1¼ Cr-½ Moly Shell & Cover	19	22	23	25	24	24	23	21	19	18	17	16	16
4-6 Percent Cr-½ Moly Shell & Cover	27	30	33	34	35	34	33	32	29	26	25	23	23
11/13 Chrome Shell & Cover	30	33	35	35	36	36	35	33	31	29	27	25	24
304 Stainless Shell & Cover	33	35	36	37	37	37	36	35	33	31	28	27	25
Monel Channel & Floating Head Cover	42	41	41	41	40	38	37	36	35	34	33	32	31
1¼ Cr-½ Moly Channel & Floating Head Cover	23	24	25	25	24	23	23	22	21	21	21	21	21
4-6 Percent Cr-½ Mo Channel & Floating Head Cover	37	38	37	37	36	35	33	30	29	27	28	27	26
11/13 Cr Channel & Floating Head Cover	38	38	37	37	36	35	34	32	30	29	28	27	27
304 Stainless Channel & Floating Head Cover	39	38	38	37	36	35	34	33	31	30	29	28	28

Values obtained from this table constitute a precentage extra for the alloy parts involved when compared with the total price of an all-steel exchanger of the same type designed for 150 psi on both shell and tube side.

cladding is available on low-chrome alloy base materials.

Where thin wrapper plates, under 3/8 inch, will meet the pressure and code requirements, solid stainless or monel often proves the economical choice because of the less costly fabricating techniques involved.

Clad material can be used to advantage for tube sheets, shell covers and floating head covers where stainless protection is required only on one side. Channel covers may be most economically protected by employing a face plate of stainless steel or brass. Plug welding of the face plate to the carbon steel cover may facilitate handling and the machining of gasket surfaces.

New developments in shielded inert gas metallic arc welding have made it economically feasible to deposit stainless weld metal facings which meet all the requirements of a corrosion-resistant lining. It is also practical to automatically deposit a single layer overlay of stainless weld metal with little dilution and minimum penetration of the base material.

Tube sheets and flanges having recessed gasket surfaces may be fully protected by a single layer deposit and machine-faced to a perfect finish. Two layers are sufficient to build up the tongue where tongue and groove is required. Stainless tubes can be rolled into these tube sheets in a manner such as to insure against penetration of the corrosive fluids into the base material of the sheet. Seal welding of the tubes to the weld deposit protected tube sheet may be employed as an added safeguard where intermixing of the shell and tube fluids would be dangerous or intolerable, and base tube sheet and tube materials are compatible from a welding standpoint.

Aluminizing. The use of metal sprays as a protection against corrosion did not obtain wide acceptance in the refining industry until recently, when a new method of providing a diffused aluminum coating was developed. This aluminum spray, or aluminizing, is a new concept in providing a corrosion and scale resisting coating on any iron base alloy. When properly applied, it provides a diffused type coating that is highly resistant to H_2S and H_2/H_2S corrosion. This coating also protects steel against heavy oxidation scaling when exposed to furnace atmospheres. Aluminizing provides

TABLE 3—Extra for Alloy Construction in Percent of Steel Base Price, 300 lb. Working Pressure

	SHELL DIAMETERS 12	14	16	18	20	22	24	27	30	33	36	39	42	Multipliers For Mixed Pressures 150		
All Steel Heat Exchanger	100	100	100	100	100	100	100	100	100	100	100	100	100			
Naval Rolled Tube Sheets & Baffles	14	17	19	21	22	22	22	22	23	24	24	25				
Monel Tube Sheets & Baffles	24	31	35	37	39	39	40	40	41	41	41	41	42			
1¼ Cr-½ Moly Tube Sheets & Baffles	6	7	7	7	8	8	8	8	9	10	10	10	11			
4-6 Percent Cr-½ Mo Tube Sheets & Baffles	19	22	24	25	26	26	26	25	25	25	26	26	26			
11/13 Cr Tube Sheets & Baffles	21	24	26	27	27	27	27	27	27	27	27	27	23			
304 Stainless Tube Sheets & Baffles	22	27	29	30	31	31	31	31	30	30	30	31	31			
Monel Shell & Cover	45	48	51	52	53	53	52	51	49	47	45	44	44	.92		
1¼ Cr-½ Mo Shell & Cover	20	22	24	25	25	25	24	22	20	19	18	17	17	.92		
4-6 Percent Cr-½ Mo Shell & Cover	28	31	33	35	35	35	34	32	30	28	27	26	26	.92		
11/13 Cr Shell & Cover	29	33	35	36	36	36	35	34	32	30	28	27	27	.92		
304 Stainless Shell & Cover	32	34	36	37	38	38	37	35	33	31	30	29	28	.92		
Monel Channel & Floating Head Cover	40	42	42	43	42	41	40	37	34	32	31	30	30	.92		
1¼ Cr-½ Mo Channel & Floating Head Cover	23	24	24	25	24	24	23	22	21	21	21	20	20	.92		
4-6 Percent Cr-½ Mo Channel & Floating Head Cover	36	37	38	38	37	36	34	31	29	27	26	25	24	.92		
11/13 Cr Channel & Floating Head Cover	37	38	39	39	38	37	35	32	30	28	27	26	25	.92		
304 Stainless Channel & Floating Head Cover	37	39	39	39	38	37	36	33	31	29	28	26	26	.92		

Values obtained from this table constitute a percentage extra for the alloy parts involved when compared with the total price of an all-steel exchanger of the same type designed for 300 psi on both shell and tube side. The right hand table provides approximate multipliers for mixed pressures which when applied to the percentage value on the same line will serve as a rough correction where the parts involved must be designed for pressures lower than 300 psi.

a pure aluminum surface layer over a diffused alloy bond layer on the base metal. In practical applications, the total coating thickness is held to about .012 inch to .015 inch which includes the bond layer of approximately .008 inch thickness. Special techniques must be used in applying the aluminizing to prevent oxidation of the surface during the hot metallizing application. This can be accomplished by hot dipping or by spraying and applying the necessary heat treating in an oxygen free atmosphere. Heat exchanger shells, channels, tube sheets and baffles may be satisfactorily aluminized. An allowance must be made on metallized parts to take care of increased dimensions caused by metallizing. This is particularly true where baffle and tube sheet holes are metallized. Large tubes have been aluminized both inside and out, and some attempts have been made to metallize small tubes (1 inch and ¾ inch) on the inside, with varying success.

COST DATA

Cost studies covering six alloys in four pressure increments were made for four shell diameters varying from 12 inches to 42 inches ID. Cost of components, such as tubes, tube bundles, shells and tube side closures were computed separately so that they can be used in almost any combination. The results of some 200 estimates were curved and interpolated for all standard shell sizes from 12 inches to 42 inches.

This mass of cost data is presented in seven easy-to-use charts and it requires only several minutes to arrive at a price from a possible 10,000-plus combinations.

Heat exchanger prices are often expressed in dollars per square foot. This unit of price will serve as a basis for the charts given herein. A standard of comparison has been chosen as the price per square foot of an all-steel heat exchanger with either ¾ or 1 inch tubes on a square cleanable pitch. Tube length is 16 feet and construction conforms with TEMA Class R Standards. This basic price can be obtained from the curves in Figures 2 and 3. A percentage increase to be applied to this base for almost any combination of the six basic alloys is then read from Tables 2, 3, 4, or 5 for design pressure increments of 150, 300, 450 and 600 pounds per square inch, respectively. All percentages obtained from Tables 2 to 5 are additive. A final additive extra in terms of dollars per square foot to cover alloy tubing can be obtained from Table 6.

In presenting the percentage increases by subassemblies, the over-all

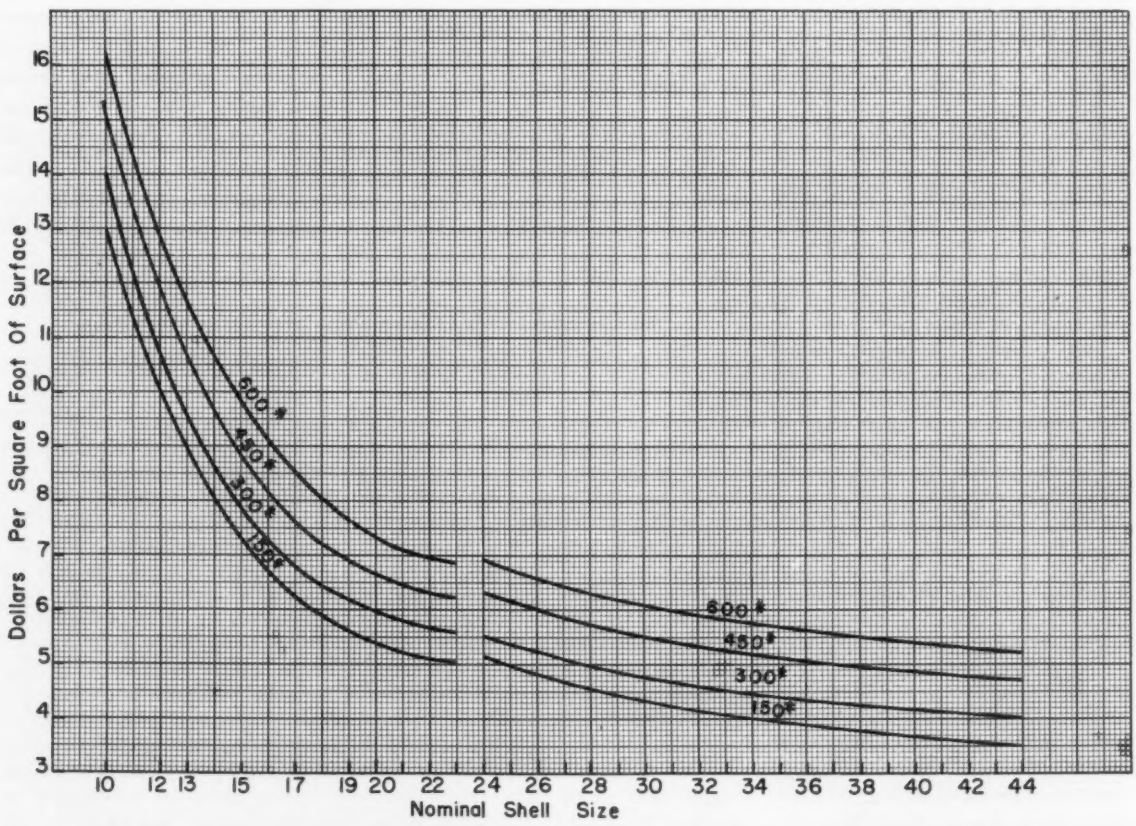

FIGURE 2—Cost per square foot, TEMA Class R, all-steel heat exchangers with ¾ or one-inch tubes.

accuracy of the pricing method is far better than any estimating short cuts heretofore available to the engineer.

How to Use the Charts. As an example of the use of the charts, determine the price of a 30-inch diameter unit with 1739 square feet of ¾ inch x 14 BWG tubes 16 feet long arranged on a 1-inch square pitch, tube material to be of 4-6 chrome; tube sheets, channel and floating head cover of 11-13 chrome; shell to be 10 percent clad 18-8 stainless steel; design pressure 450 pounds, both sides.

From Figure 2, for ¾ inch tubes, the price per square foot for a 30-inch unit, 450 pounds, is determined to be $5.50 per square foot. From Table 4, the percentage extra for 11-13 chrome tube sheets and baffles is read as 27 percent; the percentage extra for 11-13 chrome channels, channel cover and floating head cover is 30 percent, and the percentage extra for 18-8 stainless shell is 35 percent. Totalling these three percentages gives a resultant of 92 percent. Add this percentage to 100 and apply to the dollars-per-square-foot price as obtained above from Figure 2:

$$\$5.50 \times 1.92 = \$10.56$$

per square foot

The tubes, however, being 4-6 percent chrome, will cost $2.35 per

TABLE 4—Extra for Alloy Construction in Percent of Steel Base Price, 450 lb. Working Pressure.

	SHELL DIAMETERS													Multipliers For Mixed Pressures		
	12	14	16	18	20	22	24	27	30	33	36	39	42	150	300	
All Steel Heat Exchanger	100	100	100	100	100	100	100	100	100	100	100	100	100	....	....	....
Naval Rolled Tube Sheets & Baffles	14	17	19	21	22	22	22	23	23	24	25	26	27	....	....	....
Monel Tube Sheets & Baffles	24	31	35	37	39	39	40	41	41	42	42	42	43	....	....	....
1¼ Cr-½ Moly Tube Sheets & Baffles	6	7	7	7	8	8	8	9	10	10	11	11	12	....	....	....
4-6 Percent Cr-½ Moly Tube Sheets & Baffles	19	22	24	25	26	26	26	25	26	26	26	27	27	....	....	....
11½ Cr Tube Sheets & Baffles	21	24	26	27	27	27	27	27	27	28	28	28	29	....	....	....
304 Stainless Tube Sheets & Baffles	22	27	29	30	31	31	31	31	30	30	30	31	31	....	....	....
Monel Shell & Cover	51	55	57	57	56	56	55	54	52	50	48	47	46	.81	.89	....
1¼ Cr-½ Moly Shell & Cover	23	25	26	27	27	27	26	23	22	21	19	19	18	.81	.89	....
4-6 Percent Cr-½ Moly Shell & Cover	31	34	37	38	38	37	36	34	32	30	28	27	26	.81	.89	....
11½ Chrome Shell & Cover	33	36	37	39	39	39	38	36	34	31	30	28	28	.81	.89	....
304 Stainless Shell & Cover	36	39	41	41	41	40	39	37	35	33	31	30	30	.81	.89	....
Monel Channel & Floating Head Cover	42	42	43	42	40	39	37	36	33	32	31	30	30	.88	.95	....
1¼ Cr-½ Moly Channel & Floating Head Cover	25	26	26	25	24	23	23	22	22	21	21	20	20	.88	.95	....
4-6 Percent Cr-½ Moly Channel & Floating Head Cover	38	39	39	39	37	35	33	31	29	27	26	25	25	.88	.95	....
11½ Cr Channel & Floating Head Cover	38	40	40	40	37	36	34	32	30	28	27	26	26	.88	.95	....
304 Stainless Channel & Floating Head Cover	39	40	40	39	38	36	35	33	31	29	28	27	26	.88	.95	....

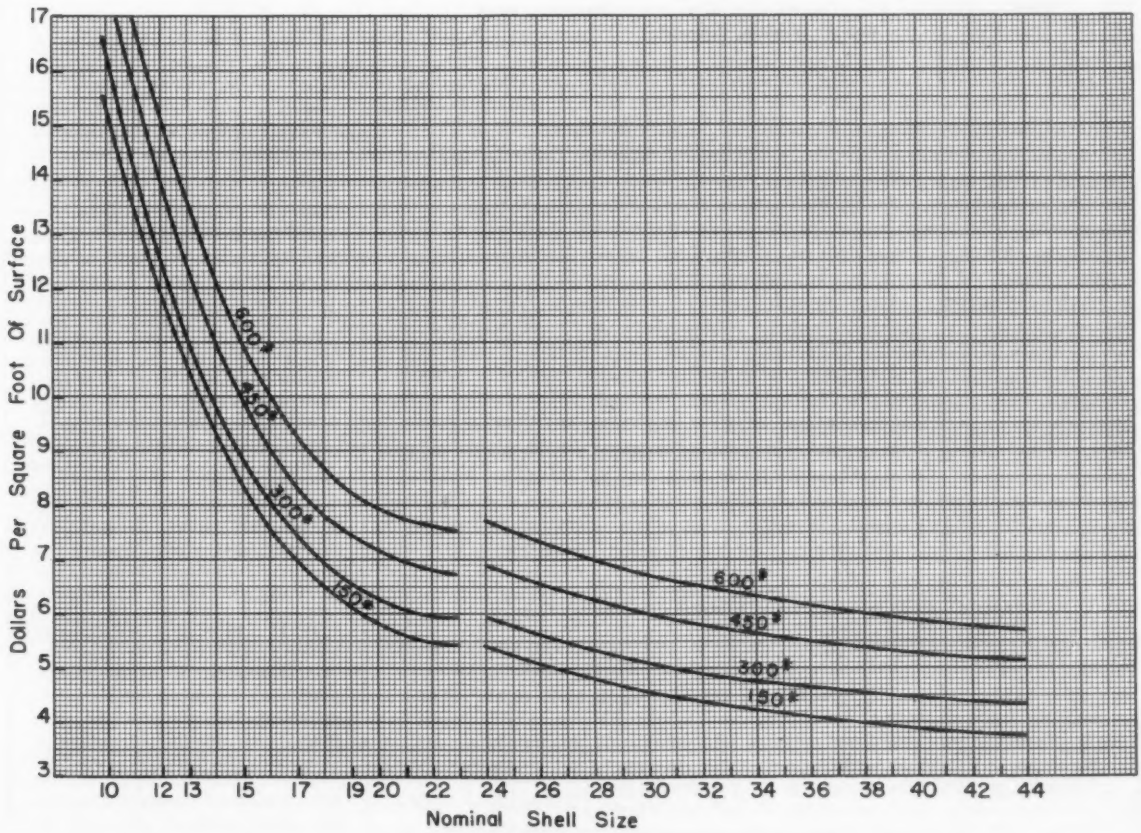

FIGURE 3—Cost per square foot, TEMA Class R, all-steel heat exchangers with one-inch diameter tubes.

square foot more than the steel tubes in the base price (from Table 6). Therefore, add this figure to $10.56 per square foot to obtain the final price of:

$$\$10.56 + 2.35 = \$12.91$$
per square foot

As is often the case, shell and tube side pressures may not be the same. To present tables similar to Tables 2 to 5 for all the possible combinations would require literally hundreds of design studies and estimates and is beyond the scope of this article. However, multipliers have been calculated which may be applied to the table percentages for shell or tube side closures when these parts are designed for a lower pressure than the base pressure. To use the multipliers, select the highest pressure as the base pressure, then multiply the applicable alloy percentage extra by the factor in the right-hand table of Tables 2 to 5 for the materials and reduced pressures involved. Multipliers for mixed pressures should never be applied to tube sheets and baffle percentage extras.

Example. Determine the percentage extra which should be applied to a 24-inch diameter all-steel unit designed for 600 pounds tube side and 300 pounds shell side, if shell and shell cover were to be made of 11-13 chrome steel. From Table 5 read 36 percent at the intersection of the 11-13 Chrome Shell and Cover line with the 24-inch Shell Diameter Column. Multiply this percentage by the factor 0.83 found on the same line under the 300 pounds column of Multipliers for Mixed Pressure. The corrected percentage is then 29.9.

TABLE 5—Extra for Alloy Construction in Percent of Steel Base Price, 600 lb. Working Pressure.

	SHELL DIAMETERS													Multipliers For Mixed Pressures		
	12	14	16	18	20	22	24	27	30	33	36	39	42	150	300	450
All Steel Heat Exchanger	100	100	100	100	100	100	100	100	100	100	100	100	100	....	....	....
Naval Rolled Tube Sheets & Baffles	14	17	19	21	22	22	22	22	23	24	25	26	27	....	....	....
Monel Tube Sheets & Baffles	23	31	34	35	36	37	39	40	41	42	43	43	43	....	....	....
1¼ Cr-½ Moly Tube Sheets & Baffles	6	6	7	7	7	7	7	8	9	10	11	11	12	....	....	....
4-6 Percent Cr-½ Moly Tube Sheets & Baffles	19	21	23	24	24	24	25	25	25	25	26	27	28	....	....	....
11½ Cr Tube Sheets & Baffles	19	20	22	24	25	26	26	26	27	27	28	29	30	....	....	....
304 Stainless Tube Sheets & Baffles	21	25	27	29	29	29	29	30	30	30	31	33	33	....	....	....
Monel Shell & Cover	56	56	55	55	55	54	54	53	51	49	48	47	46	.75	.83	.92
1¼ Cr-½ Moly Shell & Cover	21	24	25	25	26	25	25	23	21	20	19	18	18	.75	.83	.92
4-6 Percent Cr-½ Moly Shell & Cover	31	34	36	37	37	36	35	33	31	29	28	27	26	.75	.83	.92
11½ Chrome Shell & Cover	33	36	37	38	38	37	36	35	33	31	29	28	28	.75	.83	.92
304 Stainless Shell & Cover	38	40	42	42	40	39	38	37	35	32	31	30	30	.75	.83	.92
Monel Channel & Floating Head Cover	44	45	44	43	42	41	39	36	34	30	29	28	28	.78	.86	.92
1¼ Cr-½ Moly Channel & Floating Head Cover	25	25	26	26	25	23	23	22	21	20	19	19	19	.78	.86	.92
4-6 Percent Moly Channel & Floating Head Cover	38	39	39	39	38	36	34	31	28	26	24	23	23	.78	.86	.92
11½ Cr Channel & Floating Head Cover	40	41	41	40	38	36	35	32	28	26	25	24	23	.78	.86	.92
304 Stainless Channel & Floating Head Cover	40	41	41	41	39	37	35	32	29	27	26	25	23	.78	.86	.92

TABLE 6—Extra for Alloy Tubes in Dollars per Square Foot

	¾ INCH OD TUBES			1 INCH OD TUBES		
	16 BWG	14 BWG	12 BWG	16 BWG	14 BWG	12 BWG
Carbon Steel	....	0	.08	....	0	.11
Admiralty	.51	1.01	1.72	.75	1.28	2.04
1¼ Chrome-½ Moly Seamless	1.41	1.47	1.59	1.11	1.17	1.38
4-6 Chrome Seamless	2.27	2.35	2.51	1.81	1.89	2.15
11-13 Chrome Welded	3.09	3.79	4.97	2.84	3.46	4.83
Stainless-TP 304 Welded	3.46	4.26	5.56	3.24	3.91	5.46
Monel (Seamless)	4.61	5.91	7.64	4.46	5.66	7.49

Values obtained from this table represent the extra price in dollars per square foot for a tube of the material and gage shown, when compared with a steel tube of the same diameter having a 14-gage wall thickness.

The accuracy of estimated prices obtained from charts presented herein is no better than the accuracy of the all-steel base price used. As the price-per-square-foot values from Figures 2 and 3 are subject to change, it is suggested that percentages obtained from Tables 2 to 5 be applied only to up-to-date prices on comparable all steel units.

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How to Make and Use C_4 Olefins

Part 1: 1-Butene and 2-Butene

Part 2: Isobutylene

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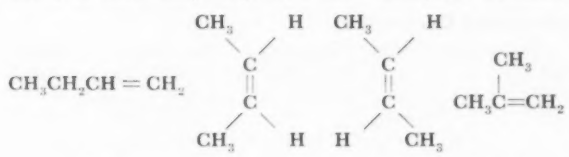
THE COMMERCIAL utilization of olefins has been concentrated in ethylene[1, 11] and propylene,[2] mainly because of their simplicity. The C_4 Olefins, the butenes,



1-Butene (α-Butylene) | *cis*-2-Butene (β-Butylenes) | *trans*-2-Butene (β-Butylenes) | Isobutylene (2-methylpropene)

present a more complex picture, however, because there are four isomers—each of which has chemical and physical similarities as well as differences.

All of the C_4 olefins will react by addition to the carbon-carbon double bond generally under milder conditions than those used for the corresponding reaction with propylene. The position of unsymmetrical addenda is determined by the alkyl group (CH_3— or CH_3CH_2—) attached to the double bond. The alkyl groups also provide a point of attack for substitution reactions (methallyl chloride) and oxidation (maleic acid). These chemical differences of the isomers are both in kind as well as in degree.

The *n*-butenes have similar chemical properties and, consequently, their chemistry and utilization will be discussed together. Their largest use (*ca* 75 percent) is in the production of butadiene. The 1959 feedstocks for butadiene in the United States are estimated at 45 to 50 percent butenes, 40 percent butane and the remainder a by-product from the hydrocarbon-cracking production of ethylene.[3] Isobutylene differs rather sharply from the straight-chain butenes in its chemical properties and utilization; consequently, are discussed separately. (Part 2).

PRODUCTION

Refinery streams are the principal source (*ca* 85 percent) of the C_4 olefins and the remainder comes from the dehydrogenation of butane. The C_4 olefins separated from refinery streams represent only about 10-15 percent of the total available from this source.

The dehydrogenation reaction

$$C_4H_{10} \rightarrow C_4H_8 + H_2$$

is endothermal and produces two molecules from one; thus, it would be favored by a high temperature and low pressure. Many processes and catalysts have been patented for the dehydrogenation of butane and isobutane. They are generally characterized by operating in the range of 525 to 600° C, at a pressure of about 100 psi, and by the use of a chromia-alumina catalyst. The conversion per pass is close to 25 percent and the unreacted feed is recycled. One pound of butane will produce 0.85 pound of butenes, 0.03 pound of hydrogen and 0.01 pound of C_1, C_2, and C_3 hydrocarbons. The ultimate yield of C_4 olefins from both butane and isobutane is 85 to 90 percent.

There is carbon formation on the catalyst which requires a catalyst regeneration step. A typical process operates with a 60-minute dehydrogenation cycle, a 1.5-minute purge, a 58-minute reactivating cycle, and a 0.5-minute depressuring and purging of the reactivated reactor.[4] The catalyst reactivation temperature must be kept below 750° C to prevent sintering of the catalyst.

Regardless of the source, the basic problem of C_4 olefin production is one of separation. Isobutylene is removed by absorption in 65 percent sulfuric acid. After the isobutylene has been removed, isobutane and 1-butene can be separated from *n*-butane and the 2-butenes by straight fractionation (see Table 1). The olefins can be separated from the paraffin hydrocarbons by extractive distillation (e.g., with furfural or acetone). There are now commercially available 95 percent pure 1-butene and 2-butene. The 2-butene is a mixture of its two geometrical isomers.

Figure 1 represents production information for mixtures of 1-butene and 2-butene. The wide and appar-

This review of where the butenes are going presents useful background data on the chemistry, production and utilization of all four isomers of butylene. Part 1 covers normal butenes and Part 2 discusses isobutylene.

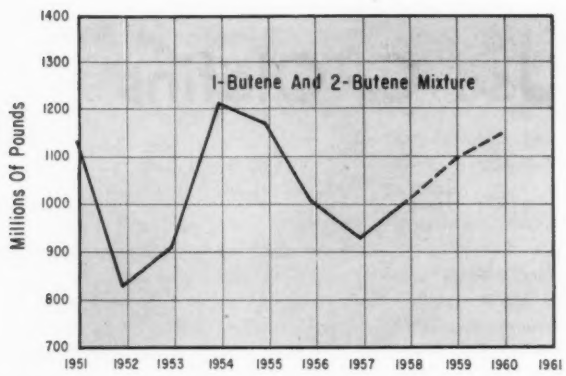


FIGURE 1—The wide and apparently aimless fluctuations of 1-butene and 2-butene production result from varying butadiene requirements.

TABLE 1—Volatility Relationship of C_4 Hydrocarbons

Compound	Boiling Point, °C	Relative Volatility At 51.6° C (125° F) and 100 psig.
Isobutane	—11.7	1.14
Isobutylene	— 6.9	1.00
1-Butene	— 6.3	.98
1, 3-Butadiene	— 4.4	.97
n-Butane	— 0.5	.86
trans-2-Butene	+ 0.9	.82
cis-2-Butene	+ 3.6	.78

ently aimless fluctuations of the data for *n*-butene mixtures are the result of varying butadiene requirements and of differences in the reporting of statistics for several of the years. The present upward trend should continue.

UTILIZATION

The chemical utilization of the normal butenes is conveniently divided into the reactions which lead to individual compounds and polymerization reactions. The chemical characteristics of 1-butene and the 2-butenes are very similar and their reactions frequently lead to the same product. The isomeric 2-butenes differ very slightly and these chemical differences are usually related to differences in rates of reaction. Addition reactions will produce different optical isomers depending on the geometry of the parent butene. These optical isomers are important to research chemists, but have no real industrial significance. The principal derivatives of the *n*-butenes are given in Figure 2.

Chemical Derivatives

Dehydrogenation—Butadiene. The dehydrogenation of the *n*-butenes to butadiene is basically an extension of the dehydrogenation of butane to the butenes.

$$C_4H_8 \rightarrow CH_2 = CHCH = CH_2$$

The feed (containing about 80 percent *n*-butenes) is preheated to about 540° C, mixed with superheated

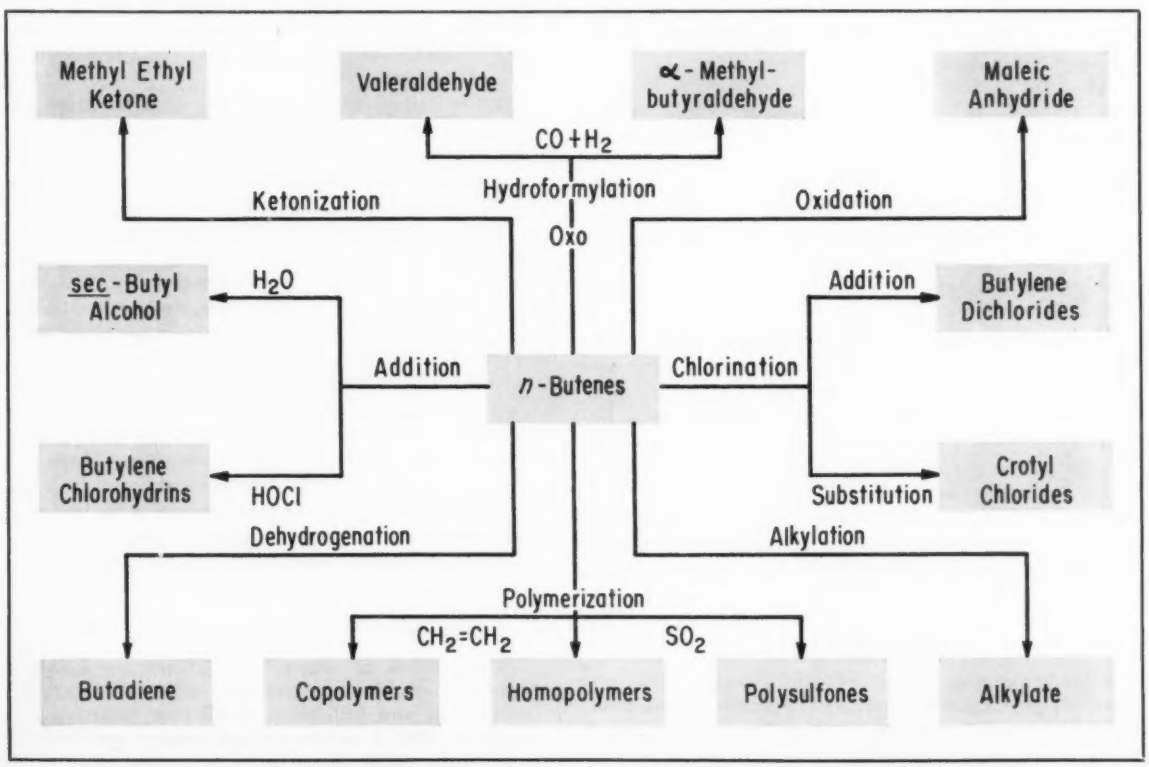


FIGURE 2—Shows a chemical family tree with actual and potential utilization of n-butenes.

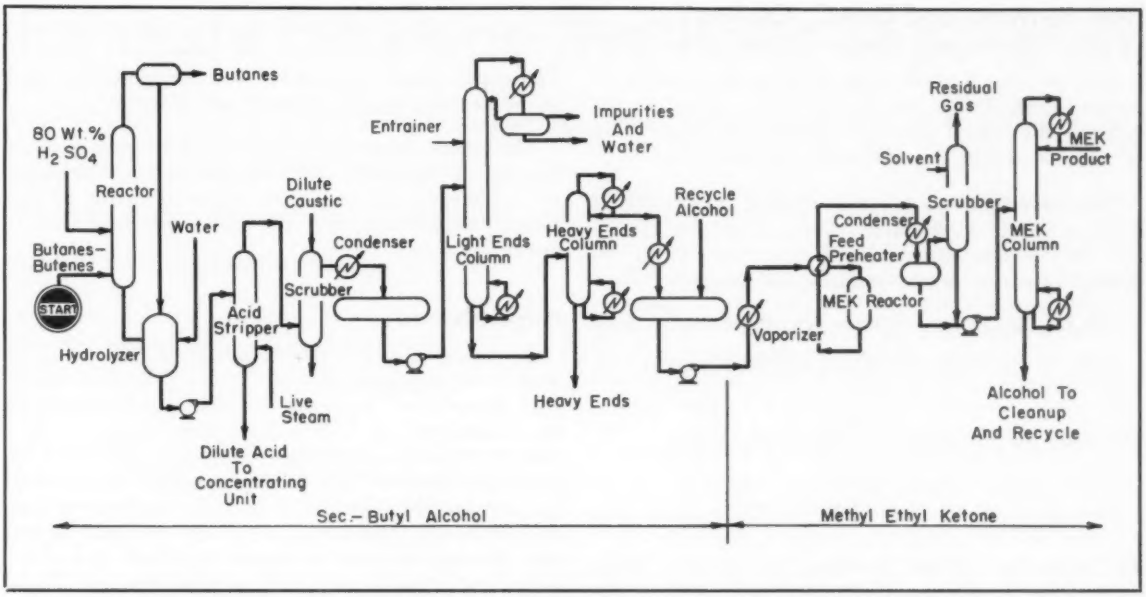


FIGURE 3—Represents a combined process for making sec-butyl alcohol and methyl ethyl ketone.

steam in a ratio of 1 to 15, and passed over a fixed-bed catalyst. The steam serves the dual function of maintaining a low hydrocarbon partial pressure and of removing the deposited carbon by the water-gas reaction.

$$C + H_2O \rightarrow CO + H_2$$

The operating temperature for the dehydrogenation is between 620 and 675° C.

This dehydrogenation reaction to produce butadiene represents the largest use of the *n*-butenes. It will grow and prosper in direct relation to the fortunes of butadiene.

Hydration—*sec*-Butyl Alcohol. The largest typically chemical use for the *n*-butenes is their hydration to *sec*-butyl alcohol.

$$C_4H_8 + H_2SO_4 \rightarrow CH_3CH_2\underset{|}{\overset{CH_3}{C}}HOSO_3H$$

$$CH_3CH_2\underset{|}{\overset{CH_3}{C}}HOSO_3H + H_2O \rightarrow CH_3CH_2CHOHCH_3 + H_2SO_4$$

A mixed feed containing both butane and *n*-butenes (30-50 percent) is contacted with 80 percent sulfuric acid in a tower reactor at 35-40° C under 2-3 atms. pressure. The conversion of the butenes to mono- and di-*sec*-butyl sulfate is essentially quantitative. The alcohol obtained from the sulfate by dilution to a 20-30 percent sulfuric acid solution is steam stripped from this dilute acid mixture.

The only important use of *sec*-butyl alcohol is in the production of **methyl ethyl ketone (MEK).**

$$CH_3CHOHCH_2CH_3 \rightarrow CH_3\overset{O}{\overset{\|}{C}}CH_2CH_3 + H_2$$

The alcohol is vaporized, preheated, and passed over a zinc oxide (or brass) catalyst at a temperature of 360-415° C. The *sec*-butyl alcohol is dehydrogenated to **MEK** in a 75 percent yield. Frequently the hydration of the butenes to *sec*-butyl alcohol and the dehydrogenation of the alcohol to **MEK** are operated as an integrated process. Figure 3 represents a combined process of this type. Official production data are not available for either **MEK** or *sec*-butyl alcohol, but it is estimated that **MEK** production is about 200 million pounds per year. *sec*-Butyl alcohol production follows closely that of **MEK.**

Ketonization—MEK. The production of **MEK** directly from the *n*-butenes by reaction with water has been patented.[5]

$$C_4H_8 + H_2O \xrightarrow{\text{cat.}} CH_3\overset{O}{\overset{\|}{C}}CH_2CH_3 + H_2$$

The conditions reported are a temperature of 305° C, and a pressure of 500 psi and a water to olefin ratio of 4-5 to one. The process uses a tungsten sulfide-nickel sulfide catalyst. The conversion per pass is about 40 percent and the yield is 35-40 percent.

Hydroformylation (Oxo)—Amyl Alcohol. The addition of carbon monoxide and hydrogen to the *n*-butenes under the influence of a cobalt carbonyl catalyst produces a mixture of n-valeraldehyde (50 percent) and 2-methylbutanal (50 percent).

$$C_4H_8 + CO + H_2 \xrightarrow{Co_2(CO)_8} CH_3CH_2CH_2CH_2CHO + CH_3CH_2\underset{|}{\overset{CH_3}{C}}HCHO$$

Under the normal operating conditions of *ca.* 175° C and 200 atm. pressure all three of the *n*-butenes will give the same ratio of products. This ratio can be changed, however, by varying the operating conditions. The con-

version per pass is in the range of 80 percent with a 75 percent yield. The aldehydes are hydrogenated to the corresponding amyl (pentyl) alcohols which are used as solvents and in the production of plasticizers.

Chlorohydrination—Butylene Oxides. A mixture of butylene oxides is produced by one company (Dow) through the chlorohydrination of *n*-butenes and the dehydrochlorination of the resulting chlorohydrins.

$$CH_3CH_2CH=CH_2 + HOCl \rightarrow CH_3CH_2CHOHCH_2Cl$$

$$CH_3CH=CHCH_3 + HOCl \rightarrow CH_3CHOHCHClCH_3$$

$$CH_3CH_2CHOHCH_2Cl \xrightarrow{\text{Base}} CH_3CH_2\underset{\diagdown\,\diagup}{\overset{O}{CH}}CH_2$$

$$CH_3CHOHCHClCH_3 \xrightarrow{\text{Base}} CH_3\underset{\diagdown\,\diagup}{\overset{O}{CH}}CHCH_3$$

The conditions for these reactions are similar to those used for the production of propylene chlorohydrin and oxide. The butenes may be chlorohydrinated at 25-50° C using dilute hypochlorous acid. The chlorohydrins are readily dehydrochlorinated to the oxide by a base.

1,2-Butylene oxide of high purity has recently been made available commercially (Carbide).

Butylene oxides are used as acid scavengers in chlorinated solvents and as a source of butylene glycols and glycol derivatives, polymers and condensation products. Their potential uses parallel the actual uses of propylene oxide.[2]

Chlorination—Butylene Dichlorides. The addition of chlorine to the *n*-butenes has not achieved any industrial significance.

$$C_4H_8 + Cl_2 \rightarrow C_4H_8Cl_2$$

The reaction will take place under mild conditions, but the resulting dichlorides are not especially useful.

Crotyl chlorides. Crotyl chlorides and 3-chloro-1-butene may be obtained by the high temperature chlorination of the *n*-butenes.

$$CH_3CH=CHCH_3 + Cl_2 \rightarrow CH_3CH=CHCH_2Cl + HCl$$

The crotyl chlorides *(cis* and *trans)* will equilibrate with 3-chloro-1-butene through allylic rearrangement.

$$CH_3CH=CHCH_2Cl \rightleftharpoons CH_3CHClCH=CH_2$$

Industrial interest in these compounds is more potential than actual.

Oxidation—Maleic Anhydride. The vapor phase oxidation of 2-butene (350° C over a supported vanadium pentoxide catalyst) has been used commercially for the production of maleic anhydride.

$$CH_3CH=CHCH_3 \rightarrow \begin{matrix} CH-C=O \\ \| \quad\; >O \\ CH-C=O \end{matrix}$$

The yields were not high and currently maleic anhydride is produced by a similar oxidation of benzene. The vapor phase oxidation of the 2-butenes has been studied extensively by Blundell and Skirrow.[6]

Alkylation—Heptenes. The reaction between propylene and the *n*-butenes yields a mixture of heptenes used for the preparation of isooctyl alcohols.[2, 7] The alkylation is carried out over a solid phosphoric acid catalyst under pressure.

Polymerization

Polybutenes. *Atactic* poly(1-butene) is a tacky liquid with a melting point of —42° C and is of little industrial importance. *Isotactic*, crystalline, poly(1-butene) has a density of *ca.* 0.91 and a melting range of 120°-130° C. This type of polymer is being produced in pilot plant quantities in Italy by Montecatini. It is recommended for films because of its high resistance to tear and its chemical stability. It is less stiff than polypropylene, thus can be used in greater thickness than polyproplyene. It can be laminated to aluminum foil, paper, and textiles and it is proposed as a cable covering and as a corrosion-resistant coating or lining.

Co-polymers. Co-polymerization of olefins is not a new field of research, but block and graft polymerization has been under intensive research and development only since 1956. Most of the work has been with ethylene, but ter-polymers and even four-component polymers are being investigated. The polymerization of *cis* and *trans*-2-butene with sulfur dioxide has been reviewed by Dainton and Ivin.[10]

The future of ethylene—1-butene co-polymers appears to be in the ability of the butene to impart improved stress cracking characteristics to the polyethylene and also to reduce low temperature brittleness. The effectiveness of this approach is sharply questioned by several companies not presently producing polymers of this type. The two companies in production (Phillips and Grace) feel that they may become more important than the homopolymers over the long term. The present areas of use are in wire and cable coatings, pipe, dishes, cook ware, rope, and detergent bottles.

The potential of co-polymers lies in the ability to vary their properties over a large range. Many new applications will result from these unique properties. The production of co-polymers with both ethylene and propylene is expected to revitalize the market for *n*-butenes.[9]

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Part 2 will appear in an early issue

Estimate Ethylene-Methane Separation

For a quick estimate of the split between ethylene and methane, use these handy charts. There is one for absorption and another for fractionation

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THE SEPARATION of methane and lighter gases from the ethylene and heavier products can be explored easily and quickly with the charts presented here. It is possible now to make a great many scouting calculations to find an optimum separation scheme. Then the more detailed and accurate computations can be confined to a small number of alternatives.

DEMETHANIZATION BY ABSORPTION

Here demethanization is achieved by absorption of the components other than methane and inerts in an inert hydrocarbon liquid, which is subsequently regenerated. Since some absorption of methane occurs while sufficient absorption of the olefinic products into the liquid is achieved, stripping of methane from the liquid and recycle to absorption is necessary. Thus both absorption and stripping operations must be considered. For these, the Souders and Brown[1]-Kremser[2] calculation method as developed by Edmister[3] is used as a basis for the short-cut approximation presented here.

An Example. The method for using Figure 1 is indicated in the figure. For instance, the degree of absorption of ethylene from a process gas in an 8 plate absorber, operating at an average temperature and pressure of —20° F and 400 psia respectively, and employing an absorption liquid rate to give an average molal L/V ratio of 1.0 is 90 percent. This value is obtained by reading up from —20° F to the 400 psig line on the ethylene curves, continuing this point horizontally to the L/V = 1.0 line, and then vertically to the 8-plate curve, where the percentage absorption is given on the right hand scale as 90 percent.

For stripping, lines A and B are introduced. From a point on the L/V line obtained as before, intercepts are made in turn vertically with line A (or B), horizontally with line B (or A), and then vertically with the curve for the appropriate number of theoretical plates. Thus, in a 2 plate methane stripper with average conditions of 100° F, 400 psia, L/V = 3.0; the percentage stripping of methane is 88.

Extension of Use. Figure 1 as first derived refers to absorption and stripping between 10 and 100 percent. It can, however, be readily extended for lower values. This is shown to the left of the figure where a logarithmic scale for low absorption has been added. This same extended scale can be used for low stripping if the B and L/V lines are extended to the right and the A line to the left in straight lines.

Derivation. Figure 1 may also be used for other components. To assist in more general applications, it may be of use to outline how Figure 1 is constructed:

Values of equilibrium constant, K, are plotted on an ordinate logarithmic scale against abscissa values of temperature. In this case the ordinate scale is drawn in to read downwards, so that a better layout of curves is obtained. This scale is indicated down the right hand side of Figure 1. Reading upwards therefore gives values of 1/K, if reciprocal values are given to the logarithms.

Straight lines for different values of L/V are added to give an abscissa logarithmic scale of values of L/VK, i.e. of the normal absorption factor, A. This scale is indicated along the top of Figure 1. The Edmister diagram[3] relating percentage absorption with number of plates and absorption factor is then constructed on this scale for A.

It is convenient to use the same figure for both stripping and absorption calculations. Values of stripping factor, $S = \frac{1}{A}$, are obtained by taking advantage of the fact that values of A are obtained as a logarithmic scale. Two lines, A and B are drawn equally sloped in opposite directions from A = 1, as in the Figure 1. Then any value of A is transformed to the reciprocal value S, by the simple geometric procedure described earlier in the example for stripping, and without any further alteration to the figure, the percentage stripping can be read off on the percentage absorption scale.

It should be emphasized that the figure is intended for scouting experiments. It is approximate in that the average, rather than terminal, or plate-to-plate, conditions are taken for the absorber or stripper. Also, if very "heavy" gases or aromatic absorption liquids are used, the equilibrium constants, which refer to hydrogen/methane/ethylene equilibria in aliphatic solvents, will be in error.

DEMETHANIZATION BY FRACTIONATION

The difficulty of demethanization is perhaps reflected in the number of variations that have been developed. Demethanizers have been constructed for operating pressures from 50 to over 500 psi. This implies a wide range of possible operating temperatures and it is obviously important to fix the level of refrigeration required —whether produced by a compression cascade system, by auto-refrigeration, etc.—and to correlate it with the process compression load and other functions of the operating conditions of the system.

Ethylene Loss in Off-Gas. The temperature level must be sufficiently low for liquid reflux to be made at the operating pressure, i.e. off-gas dewpoint must be obtained. In this connection the loss of ethylene product into the off-gas is an important factor—a higher temperature can be used if a high loss of ethylene can be tolerated.

However, off-gas dewpoint determinations for a wide

Estimate Ethylene-Methane Separation...

range of conditions and gas composition involve a considerable amount of computation and equilibrium chart checking. Figure 2 has been constructed so that the ethylene content of off-gas at dewpoint can be established rapidly for off-gas of different compositions at different pressures and temperatures.

An Example. The value of K_e is obtained for the temperature and pressure assumed from the lower part of the figure. The value of r, which is the ratio of mol. concentration of methane to methane plus hydrogen in the off-gas, is then used in the upper part of the figure, as indicated by the chain line, to obtain the value of r/α for the same assumed temperature and pressure. The mol. fraction ethylene lost in the off-gas is given to a close approximation when the loss is small by the difference $K_e - r/\alpha$.

Hence for off-gas, with $r = 0.6$, at $-190°$ F and 200 psia, $K_e = 0.037$ and $r/\alpha = 0.027$. The mol. fraction of ethylene in the off-gas is $0.037 - 0.027$ or 0.010.

Derivation. If the mols in the off-gas and the liquid to vapor equilibrium constants at the temperature and pressure of ethylene, methane, and hydrogen (including inerts) are respectively e, m, h and K_e, K_m, K_h, then at dew point

$$e + m + h = \frac{h}{K_h} + \frac{m}{K_m} + \frac{e}{K_e} \qquad (1)$$

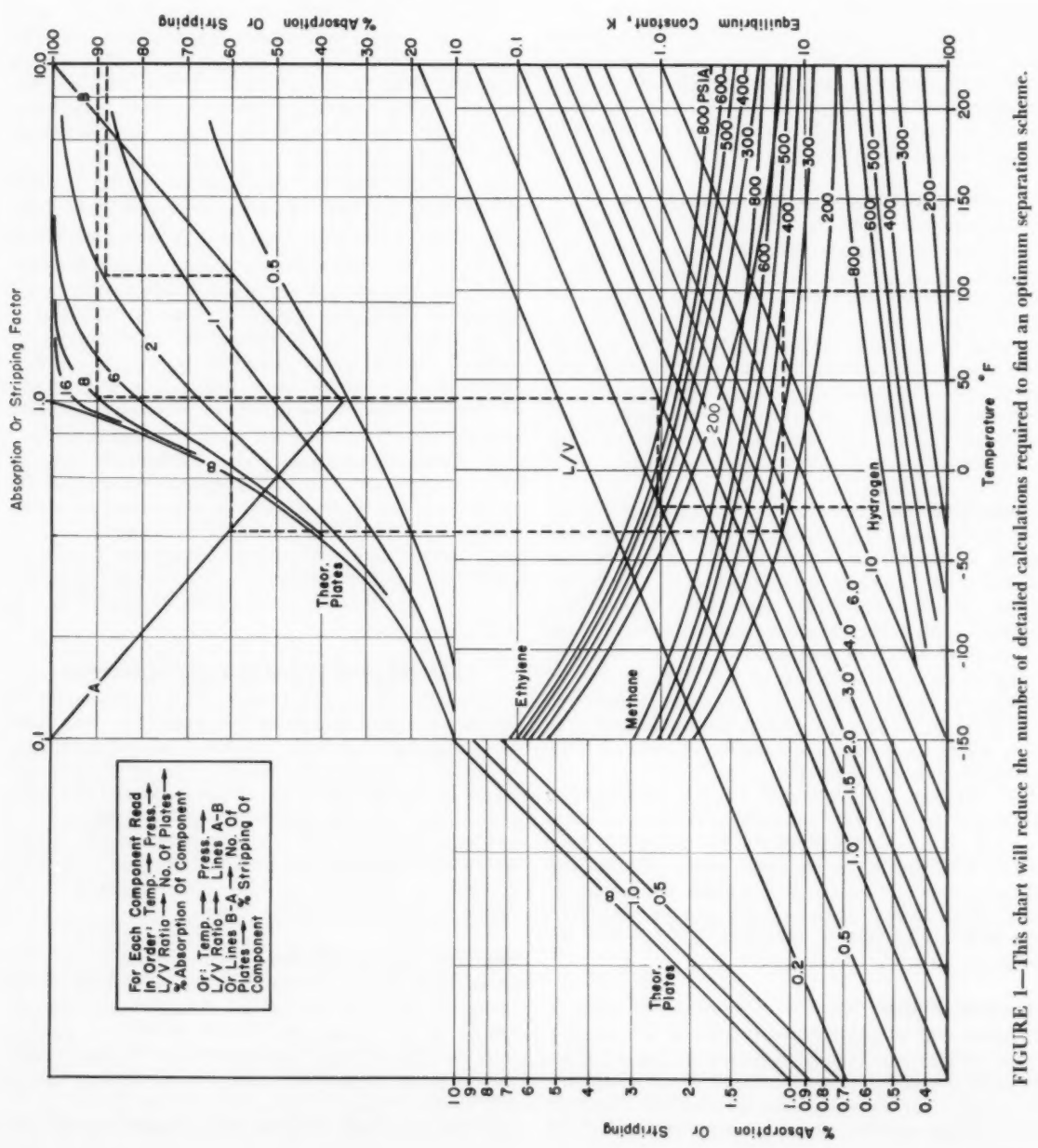
% Absorption Or Stripping
Equilibrium Constant, K
Absorption Or Stripping Factor
Temperature °F
800 PSIA
600
500
400
300
200
L/V
Hydrogen
Ethylene
Methane
Theor. Plates
For Each Component Read In Order: Temp. → Press. → L/V Ratio → No. Of Plates → % Absorption Of Component
Or: Temp. → Press. → L/V Ratio → Lines A-B Or Lines B-A → No. Of Plates → % Stripping Of Component

FIGURE 1—This chart will reduce the number of detailed calculations required to find an optimum separation scheme.

and setting $\frac{m}{m+h} = r$, the Equation (1) becomes

$$\frac{e}{m+h} = r\left[\left(\frac{K_m-1}{K_m}\right)\left(\frac{K_e}{1-K_e}\right) - \left(\frac{K_h-1}{K_h}\right)\left(\frac{K_e}{1-K_e}\right)\right] + \left(\frac{K_h-1}{K_h}\right)\left(\frac{K_e}{1-K_e}\right) \quad (2)$$

Equation (2) may be simplified as follows:

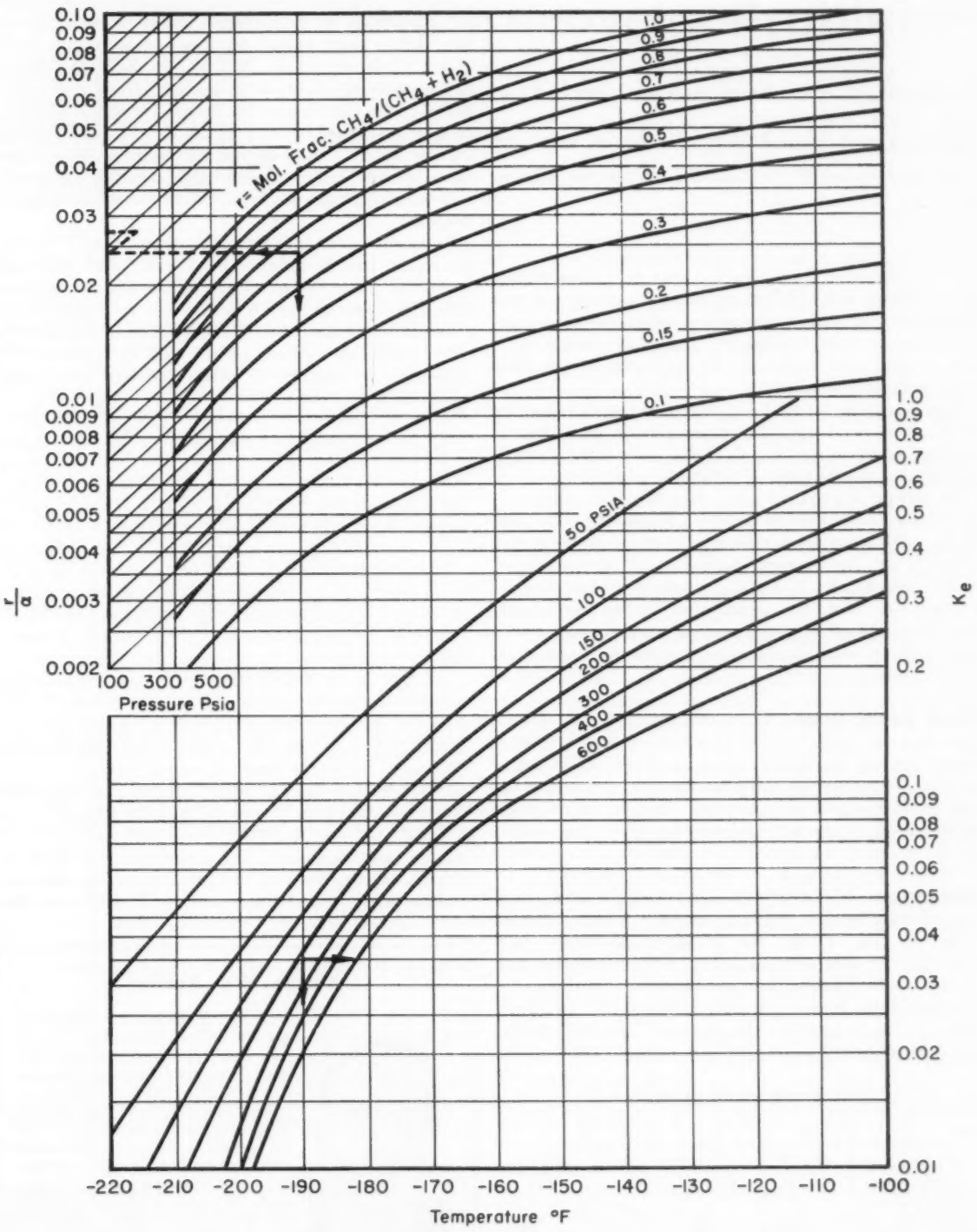

FIGURE 2—For small values of r/α, the mol fraction of ethylene in the off-gas is $K_e - r\ \alpha$.

Estimate Ethylene-Methane Separation...

The equilibrium constant of hydrogen is measured in tens and hundreds over the range of conditions appropriate here. Therefore it is a reasonable assumption to replace $\frac{K_h - 1}{K_h}$ by unity. Equation (2) then reduces to

$$\frac{e}{m+h+e} = \frac{1}{1-\frac{r}{\alpha}} \cdot \left[K_e - \frac{r}{\alpha}\right] \qquad (3a)$$

where α is the relative volatility of methane to ethylene (i.e. K_m/K_e).

For small values of r/α, Equation (2) further reduces to

$$\frac{e}{m+h+e} = K_e - \frac{r}{\alpha} \qquad (3b)$$

It will be noted from Figure 2 that the highest value of r/α shown is 0.1. Remembering the accuracy of the equilibrium constants themselves is, in general, not claimed to be more than about 7 percent, Equation (3b) can be used with confidence for low losses of ethylene (up to, say, 10 percent).

It may also be pointed out that the error in equating $1/(1-r/\alpha)$ with unity is compensated in some degree by that in equating $(K_h - 1)/K_h$ with unity, which acts in the reverse sense, although to a smaller extent.

In solving Equation (3b) graphically as Figure 2 one further simplification has been made. The variation of K_m with pressure is different at different temperatures. It can be assumed, however, that the variation of the ratio $K_m/K_e = \alpha$ with pressure is independent of temperature over the temperature range considered here. Thus the effect of pressure on α and thence on r/α can be given very simply as in the top left hand part of the figure.

Rapid Rough Guide. From equation (3b) it will be seen that the mol fraction of ethylene in the off-gas cannot exceed K_e, approaching this value when there is a large fraction of inerts in the gas. A rough rule can be formulated that the mol fraction of ethylene in off-gas is given very approximately by two-thirds of the value of the equilibrium constant for ethylene.

Comparison of Equations. Value of the mol fraction of ethylene lost derived from the rigorous Equations (1) and (2) and the simplified Equations (3a) and (3b) are compared in Table 1 for four typical sets of conditions. The results have been calculated to several significant figures solely to illustrate the difference between the equations; the data are not sufficiently accurate to specify the results to this degree of precision.

TABLE 1—Comparison of Equations

Case	I	II	III	IV
r	0.7	0.7	0.7	0.3
Temperature, °F.	—145	—145	—200	—145
Pressure, p.s.i.a.	200	450	100	450
Values of Mol. fraction C_2H_4 in Off-gas:				
Eqn. (1), (2)	.1313	.0414	.0167	.0932
Eqn. (3a)	.1316	.0417	.0169	.0942
Eqn. (3b)	.1227	.0379	.0166	.0905
$\frac{2}{3} K_e$	.1267	.0867	.0240	.0867

Reflux Ratio and Plates. Having established the appropriate conditions for attaining liquid reflux without undue loss of ethylene it is necessary to determine the reflux ratio and number of plates required in the fractionator for the required sharpness of separation between ethylene and methane.

A detailed discussion of short-cut fractionation calculation methods for multi-component system is not necessary here, since many excellent reviews are available.[3, 4, 5] It should be sufficient to indicate a series of equations by which the reflux ratio for a given number of plates can be derived. Because of the wide difference in properties of components, demethanizer systems can be widely non-ideal, but in the main these equations provide results of sufficient accuracy (generally to less than 20 percent error) for most scouting calculations.

Equation 4 is by Fenske;[6] Equations 5 and 6 by Underwood;[7] and Equation 7 by Mason.[8] The minimum number of plates and minimum reflux ratio are obtained from Equations 4, 5 and 6, where Θ is a constant which is evaluated in Equation 5 and applied in Equation 6. These minimum values are then used in Equation 7 to correlate the number of plates required with other values of reflux ratio.

$$N_{min} \log \cdot \alpha_{me} = \log \frac{x_{mD}}{x_{mB}} \cdot \frac{x_{eB}}{x_{eD}} \qquad (4)$$

$$1 - q = \sum \frac{\alpha x_f}{\alpha - \Theta} \qquad (5)$$

$$R_m + 1 = \sum \frac{\alpha x_D}{\alpha - \Theta} \qquad (6)$$

$$\left[\frac{R - 0.9\,R_{min}}{R_{min}^{0.8}}\right]^{0.75} \left[\frac{N - N_{min}}{N_{min}^{0.9}}\right] = 0.66 \qquad (7)$$

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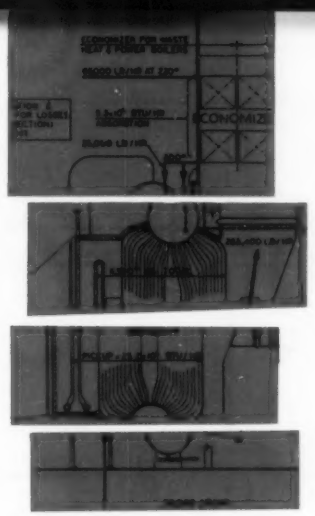


4 Solutions to the Gas Turbine Heat Recovery Problem

Spending money studying various heat recovery systems can mean savings in turbine applications for process plants

G. L. Morris, Brown & Root, Inc., Houston

A FEW DOLLARS well spent early in a project can easily save you thousands of dollars in construction costs and a greater amount during future years of operation. With the current high costs of construction, labor, and fuel, the design engineer should make complete economic studies of each installation. In addition, he should keep current with the recent developments in new equipment and techniques and not fall into the habit of being a so-called "bookshelf engineer." One of these techniques is the application of the gas-turbine-exhaust heat-recovery cycle to a modern petrochemical processing plant.

Efforts to improve the cycle efficiency of the gas turbine have, in general, been limited to the cycle itself. Except for larger capacity units, the designs have been essentially standardized. Engineering gas turbine installations is now primarily involved with the use of the turbine as an integral part of an over-all system.

For example, take a look at the design of a system requiring drives for process equipment, coupled with a demand for process steam.

For this particular application, the proven capabilities of the gas turbine for specialized use as a prime mover dictated its selection for driving large compressors to support the process system.

A normal by-product of turbine operation is large quantities of high-temperature exhaust gases with high oxygen content. The heat potential in these exhaust gases can be used in a steam generation system in the following manner:

- To heat feedwater for the steam plant and for process use.
- To generate steam in an exhaust heat-recovery boiler.
- To serve as a source of preheated combustion air for a fired boiler.

The design problems were to find combinations of the foregoing to give maximum over-all thermal efficiency consistent with specified requirements for the particular process.

Design Conditions. The first problem was to find the over-all heat balance and to determine the most economical cycle for exhaust-gas heat recovery. This heat-recovery system was to form an integral part of a petrochemical plant, and the design requirements and limitations were established common to the total plant as follows:

- **Reliability** was of foremost importance, since even a temporary shutdown could be costly. This required equipment back-up and multiple reliable units.
- **Flexibility** must permit operating at varying levels, depending on plant process load, requiring equipment capable of efficient operation at partial loads and sensitive to rapid load changes.
- **Availability** of steam for plant start-up and other operations during gas turbine shutdown required a source of steam independent of the gas turbine exhaust heat recovery system.
- **Economy** of operation dictated the use of the cheapest available common fuel for both the gas turbines and power boilers and a maximum recovery of heat from the gas turbine exhaust.
- **Simplicity of Operation.** The plant was to be located outside the United States, and simplicity of operation and design was important in that operators and maintenance personnel must be selected and trained from an inexperienced native labor pool.

The chemical processes of the plant dictated the various steam pressures and quantities, and the engineers selected the various steam-driven prime movers for the final system steam balance. Basically, the requirements of the utility section of this plant were as follows:

1. 64,500 lb/hr of steam at 425 psig and 500° FTT.
2. Additional steam would be required for operation of utility area auxiliaries and 28,000 lb/hr for the gas-turbine starting turbines.
3. 100,000 lb/hr of hot deaerated water at 550 psig for use in the chemical-process equipment.

The initial requirement for gas-turbine drives was for two simple-cycle 7000-hp units to burn treated bunker C fuel. The supplementary fuel for the boilers would be untreated bunker C.

The turbine-exhaust gas at full-load operation would have the following characteristics:

Quantity, lb/hr each	349,000
Temperature, °F (max)	860
Back pressure on turbine exhaust, inches H_2O (max)	10

Heat-Recovery Systems. Since unfired recovery boilers are dependent on the prime mover for their source

of heat, they are basically a constant heat-input boiler and are unable to meet changes in steam load. The process section of this plant governed their steam capacity through the load requirements of the gas-turbine-driven equipment. The pressure and temperature of the generated steam were also governed by the particular processes used in this plant. Because of the local power situation, the gas turbines were to have 1000 hp steam starting turbines in lieu of electric motors. With all the foregoing conditions and data taken into consideration, four basic heat-recovery solutions were made to evaluate the cycle design and determine which was best suited for this installation. The four solutions were as follows:

- One combination recovery-power boiler which would use the exhaust of both turbines.
- Two combined recovery-power boilers, one for each gas turbine.
- Two recovery boilers and one separate power boiler of 35,000 lb/hr capacity.
- Two recovery boilers and one separate power boiler of 70,000 lb/hr capacity.

The fuel-oil storage area, treatment of fuel oil, pump and heater sets, boiler feed pumps, and the cooling-water system would be basically the same for all solutions. Since the foregoing equipment is common to all solutions and since the effect of each on the heat cycle is the same, they are not shown on any of the heat-balance figures. The power-plant auxiliaries such as the deaerator and water treatment would be identical for all solutions, but would change the heat balance slightly as the steaming capacity varied; therefore, they are shown on the heat-cycle balances for each solution.

Solution 1—Single Combined Recovery and Power Boiler. The single combined recovery-power boiler would have the gas-turbine-exhaust ductwork system arranged so that, with one gas turbine running, the other gas turbine would exhaust to a stack until it was up to speed and operating satisfactorily. This requires the use of four large, expensive, high-temperature, high-pressure-type dampers. Such an arrangement would be necessary for safety reasons since it would be quite possible that the turbine could have a false start and exhaust an explosive mixture into the boiler. The gas stream from the turbines would also have to be split at the combined boiler and only a portion of this gas induced to the wind box for combustion at all loads with the balance being induced at the rear of the furnace. At partial-load operation with supplementary firing, the efficiency of this unit would be very low since there would be considerably more combustion gas available than required for burning the fuel, and it would be basically a boiler with high excess air in the stack gas. Since the pressure drop through the unit would exceed the allowable back pressure on the gas turbine, this type of installation would also require a large induced-draft fan. If flexibility were ignored, this solution would have been satisfactory for a unit of about 300,000 lb/hr steam generation, since at this point the complete exhaust-gas stream would be induced as combustion air into the wind box and the excess air would be within reasonable limits. A forced-draft fan would be required for start-up and operation of the power boiler when the gas turbines were down.

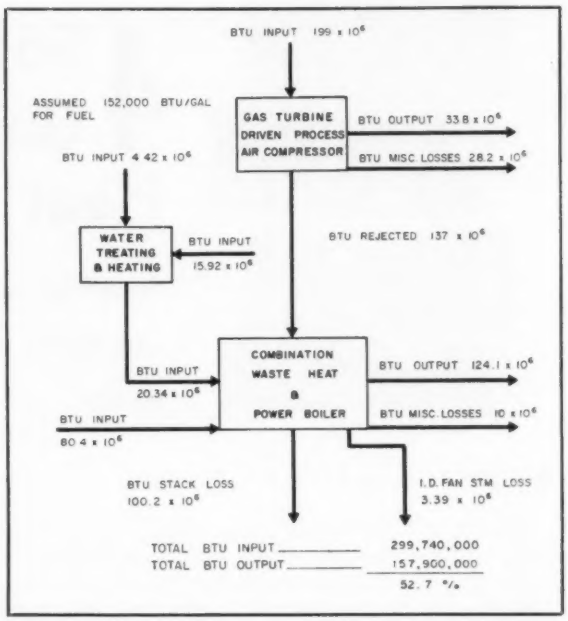

BTU INPUT 199 x 10⁶
ASSUMED 152,000 BTU/GAL FOR FUEL
GAS TURBINE DRIVEN PROCESS AIR COMPRESSOR
BTU OUTPUT 33.8 x 10⁶
BTU MISC LOSSES 28.2 x 10⁶
BTU INPUT 4.42 x 10⁶
WATER TREATING & HEATING
BTU INPUT 15.92 x 10⁶
BTU REJECTED 137 x 10⁶
COMBINATION WASTE HEAT & POWER BOILER
BTU INPUT 20.34 x 10⁶
BTU OUTPUT 124.1 x 10⁶
BTU INPUT 80.4 x 10⁶
BTU MISC LOSSES 10 x 10⁶
BTU STACK LOSS 100.2 x 10⁶
I.D. FAN STM LOSS 3.39 x 10⁶
TOTAL BTU INPUT 299,740,000
TOTAL BTU OUTPUT 157,900,000
52.7 %

FIGURE 1—Heat balance—Solution 1—One combination waste-heat and power boiler. Note: Total output same for Solution 2.

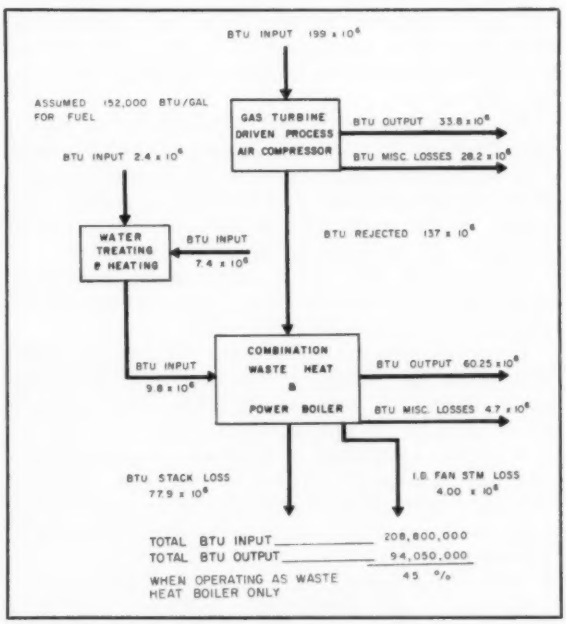

BTU INPUT 199 x 10⁶
ASSUMED 152,000 BTU/GAL FOR FUEL
GAS TURBINE DRIVEN PROCESS AIR COMPRESSOR
BTU OUTPUT 33.8 x 10⁶
BTU MISC LOSSES 28.2 x 10⁶
BTU INPUT 2.4 x 10⁶
WATER TREATING & HEATING
BTU INPUT 7.4 x 10⁶
BTU REJECTED 137 x 10⁶
COMBINATION WASTE HEAT & POWER BOILER
BTU INPUT 9.8 x 10⁶
BTU OUTPUT 60.25 x 10⁶
BTU MISC LOSSES 4.7 x 10⁶
BTU STACK LOSS 77.9 x 10⁶
I.D. FAN STM LOSS 4.00 x 10⁶
TOTAL BTU INPUT 208,800,000
TOTAL BTU OUTPUT 94,050,000
WHEN OPERATING AS WASTE HEAT BOILER ONLY
45 %

FIGURE 2—Heat balance—Solution 1 or 2 operating as a recovery boiler only.

There would be complications in the design of the gas burners since the wind-box temperature would be approximately 825° F or higher. With the boiler operating at light loads, it would also be very difficult to maintain a stable flame with this mass flow of gas through the unit. A tube failure or any other difficulty with this single combined boiler would disrupt completely the operation of the chemical plant because of

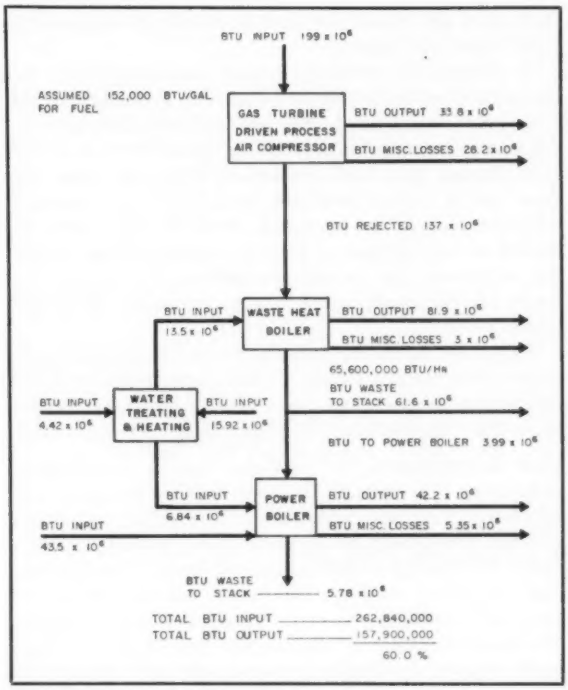

BTU INPUT 199 x 10⁶
ASSUMED 152,000 BTU/GAL FOR FUEL
GAS TURBINE DRIVEN PROCESS AIR COMPRESSOR
BTU OUTPUT 33.8 x 10⁶
BTU MISC. LOSSES 28.2 x 10⁶
BTU REJECTED 137 x 10⁶
BTU INPUT 13.5 x 10⁶
WASTE HEAT BOILER
BTU OUTPUT 81.9 x 10⁶
BTU MISC. LOSSES 3 x 10⁶
65,600,000 BTU/Hr
BTU WASTE TO STACK 61.6 x 10⁶
BTU INPUT 4.42 x 10⁶
WATER TREATING & HEATING
BTU INPUT 15.92 x 10⁶
BTU TO POWER BOILER 3.99 x 10⁶
BTU INPUT 6.84 x 10⁶
POWER BOILER
BTU OUTPUT 42.2 x 10⁶
BTU MISC. LOSSES 5.35 x 10⁶
BTU INPUT 43.5 x 10⁶
BTU WASTE TO STACK 5.78 x 10⁶
TOTAL BTU INPUT 262,840,000
TOTAL BTU OUTPUT 157,900,000
60.0 %

FIGURE 3—Heat balance—Solution 3—Two waste-heat boilers and one 35,000 lb./hr. power boiler.

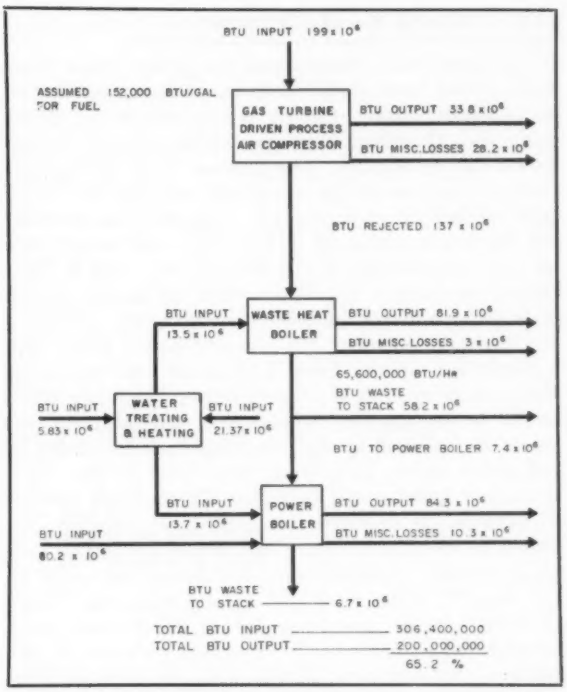

BTU INPUT 199 x 10⁶
ASSUMED 152,000 BTU/GAL FOR FUEL
GAS TURBINE DRIVEN PROCESS AIR COMPRESSOR
BTU OUTPUT 33.8 x 10⁶
BTU MISC. LOSSES 28.2 x 10⁶
BTU REJECTED 137 x 10⁶
BTU INPUT 13.5 x 10⁶
WASTE HEAT BOILER
BTU OUTPUT 81.9 x 10⁶
BTU MISC. LOSSES 3 x 10⁶
65,600,000 BTU/Hr
BTU WASTE TO STACK 58.2 x 10⁶
BTU INPUT 5.83 x 10⁶
WATER TREATING & HEATING
BTU INPUT 21.37 x 10⁶
BTU TO POWER BOILER 7.4 x 10⁶
BTU INPUT 13.7 x 10⁶
POWER BOILER
BTU OUTPUT 84.3 x 10⁶
BTU MISC. LOSSES 10.3 x 10⁶
BTU INPUT 80.2 x 10⁶
BTU WASTE TO STACK 6.7 x 10⁶
TOTAL BTU INPUT 306,400,000
TOTAL BTU OUTPUT 200,000,000
65.2 %

FIGURE 4—Heat balance—Solution 4—Two waste-heat boilers and one 70,000 lb./hr. power boiler.

the lack of steam for process equipment. The preliminary heat balance of this arrangement is shown on Figure 1. Heat losses through the stack dampers are not noted on this heat balance, but would be considerable.

You may ask why this solution was even considered since it offers practically no flexibility. The answer is that the selection of any of the four solutions is purely a matter of economics. If the efficiency and installed cost of the first solution proved to be less than the other solutions, the flexibility or any other desired condition may have been sacrificed.

Solution 2—Two Combined Recovery-Power Boilers. The two combined recovery-power boilers would basically be the same as given in Solution 1, except for the size and rating.

This arrangement would require a separate stack for each recovery-power unit with two large high-pressure, high-temperature dampers in each of the turbine-exhaust ducts. The gas stream would still split at the boilers with only a portion of the gas going to the wind-box and the balance being induced into the rear of the furnace. The efficiency of these units at full load would be approximately the same as the single combined boiler as given in Solution 1 but would have the advantage of added flexibility. For this mass gas flow one gas turbine, this solution would have had very good efficiency if the boiler rating were 150,000 lb/hr or greater. There would still be complimations in design because of the high wind-box temperatures, and here again, at light loads it would be difficult to maintain a stable flame. Both forced-draft and large induced-draft fans would be required. The outage of one of these boilers, as a result of tube failure or any difficulty would still allow the chemical plant to operate at half-capacity. As compared to Solution 1, the ductwork would be simpler and a more realistic and operable plant layout could be achieved. Total output of the two units will be essentially the same as shown on the preliminary heat balance in Figure 1. Figure 2 shows the operation of either Solution 1 or 2 when operating as a recovery boiler only.

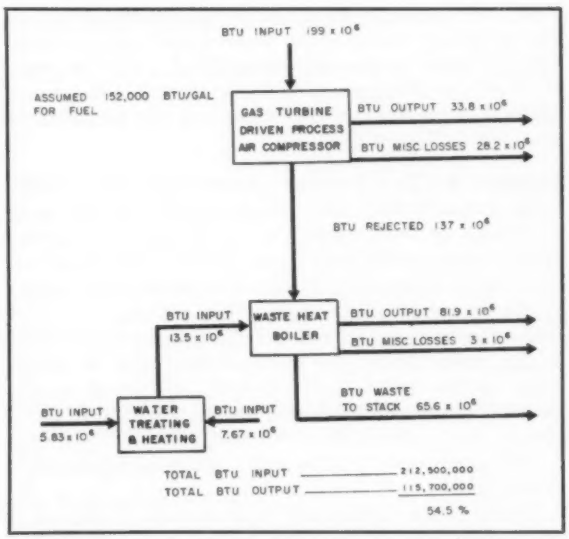

BTU INPUT 199 x 10⁶
ASSUMED 152,000 BTU/GAL FOR FUEL
GAS TURBINE DRIVEN PROCESS AIR COMPRESSOR
BTU OUTPUT 33.8 x 10⁶
BTU MISC. LOSSES 28.2 x 10⁶
BTU REJECTED 137 x 10⁶
BTU INPUT 13.5 x 10⁶
WASTE HEAT BOILER
BTU OUTPUT 81.9 x 10⁶
BTU MISC. LOSSES 3 x 10⁶
BTU WASTE TO STACK 65.6 x 10⁶
BTU INPUT 5.83 x 10⁶
WATER TREATING & HEATING
BTU INPUT 7.67 x 10⁶
TOTAL BTU INPUT 212,500,000
TOTAL BTU OUTPUT 115,700,000
54.5 %

FIGURE 5—Heat balance—Solution 3 or 4 with recovery boilers only in operation.

Solution 3—Two Recovery Boilers and One 35,000-lb/hr Power Boiler. One recovery-type watertube boiler would be furnished for each turbine and one 35,000-lb/hr power boiler. Since this recovery boiler would not

be equipped with burners and the power boiler ductwork would have isolation dampers, the possibility of an explosion during start-up in this unit would be remote and, therefore, a separate stack and gas by-pass would not be required. The pressure drop through the recovery unit would be much less and the use of an induced-draft fan would not be required. The gas leaving the boiler section of this recovery unit would have an exit temperature of approximately 525° F. This stream would then be divided with the major portion of it going into a stack-type economizer for preheating the feedwater for both this unit and power boiler, and a controlled amount being introduced into the power boiler as combustion air. The stream to the power boiler would be limited by a controlling-type damper that would be actuated by the combustion-control system of the power boiler. This would mean that at light loads the power boiler would only take the necessary amount of exhaust gas required for combustion, and the rest would be diverted uncontrolled through the stack feedwater heaters to atmosphere. The gas at this point in the recovery boiler would be at approximately 1 inch of water positive pressure due to the pressure drop through the stack feedwater heaters. As a result of this positive wind-box pressure and since the mass gas flow would be only 20 percent of the total gas-turbine exhaust, the required induced-draft fan for the power boiler would be very much smaller than in either Solution 1 or 2. Neither an economizer nor an air preheater section would be needed in the power boiler and the boiler exit gas would be approximately 600° F, or 75° F above the inlet gas temperature to the wind box of the power boiler. The preliminary heat balance of this arrangement is shown on Figure 3.

Solution 4—Two Recovery Boilers and One 70,000-lb/hr Power Boiler. This scheme would have the same watertube recovery boilers as in Solution 3, but the power boiler would have more capacity and, therefore, the over-all efficiency is the result of added heat pickup in the recovery-boiler economizer due to the increased water flow and also becausee of the increased generation in the power boiler, the most efficient item of equipment in the cycle. The ductwork, equipment layout, controls, and operation would also be identical to Solution 3.

The preliminary heat balance of this arrangement is shown on Figure 4.

Figure 5 is a preliminary heat balance of solution 3 or 4 when only the recovery boilers are in operation. This heat balance was made only to establish the efficiency and capacity of the recovery boilers and determine the requirements of the power boiler.

Modification. In the design phase of the project as more information was received and before the boiler was purchased, modifications to Solution 4 were made which would utilize more of the available heat in the turbine gas stream. Originally, the hot deaerated water for the process area was to be taken directly from a deaerator operating at 20 psig. By installing an economizer section in the recovery-boiler stack, this water to the process area could be heated to about 310° F. This would increase the capacity of the process equipment and also make the start-up of the process equipment safer and faster.

A temperature-sensing element was installed in the gas-turbine exhaust stream to actuate a damper in the inlet combustion air to the gas turbine. The turbine-exhaust gas temperature could be maintained at a high level during part-load operation. With less mass gas flow and a higher available heat head, the recovery efficiency would be increased. Positive stops were installed on this damper to prevent closure and the resulting extremely low oxygen content in the turbine exhaust which would cause loss of flame in the power boiler.

For added flexibility and also in part because of additions to the process section of this plant. Solution 4 was further modified in that two 40,000-lb/hr power boilers were to be installed in lieu of the one 70,000-lb/hr unit.

Cost Comparison. The estimated cost of the complete installation for each of the four possible solutions was tabulated. This not only included the major equipment cost but also the cost of foundations, piping, controls, ductwork, and all other associated items. The installed cost per pound of steam generation was calculated and used as a yardstick to evaluate further each solution. The most expensive installation was that of the two combined recovery-power boilers and the most economical was that of the two recovery boilers and one 70,000 lb/hr boiler.

System Selection. With one recovery boiler and one power boiler for each gas-turbine installation, the flexibility of the system would be the greatest. In this scheme, one power boiler would be capable of carrying the complete plant steam load when both recovery boilers were operating and the other power boiler would be needed only for plant start-up or when one recovery boiler was out of service. The problems in ductwork and plant layout would be much simpler. The efficiency of each cycle would be basically the same as shown on Solution 4. This solution would also allow the outage of one power boiler for annual inspection or from faulty operation without curbing the chemical plant production. By passing the 525° F exhaust gas into the idle power boiler in controlled amounts will keep this boiler in a hot standby condition and it could be fired and brought to pressure in a minimum amount of time. Keeping the standby boiler in this hot condition would almost completely eliminate deterioration and corrosion of this idle unit. It was the recommendation of the engineers that this general arrangement be utilized. Figure 6 shows the general arrangement of the equipment and also the heat balance of one complete unit as installed. The ease of operation and the efficiency of this installation in operation was even better than expected. ##

About the Author

George L. Morris is the power engineer in charge of power plant design with Brown & Root, Inc., Houston. Morris received a B.S. in mechanical engineering from Rice Institute in 1943. He has also had mechanical design experience with The Dow Chemical Co. and Texas Pipe Bending Co. He is a registered engineer in Texas and Louisiana and is a member of ASME.

Operator's Handbook for Gasoline Plants

PART 9—Positive Displacement Meters. One of a series that simplifies operations and equipment for the new and experienced operator in a natural gasoline plant

Manufacturing Department, Tennessee Oil Refining Co.
A Division of Tennessee Gas Transmission Co., Houston

THE POSITIVE DISPLACEMENT METER is an instrument used to measure flow when high accuracy is required. That's why the operator should give special attention to metering and why this part was singled out from Part 3 on instruments. Accurate measurement is preceded by meter proving and correct maintenance.

The positive displacement meter is in reality a highly efficient fluid motor. It consists of a measuring chamber and a sealing section between the inlet and outlet connections. These meters are operated by fluid pressure, and the discharge is essentially the product of piston displacement or the cross-sectional area of the measuring chamber. In other words, the piston or vane is designed to cover the fixed path of constant cross-sectional area and on each revolution of the meter, the constant cross-sectional area (measuring chamber) is returned upstream for the next displacement, and so forth. Or, more simply, the fluid stream is divided into segments, and the movement of these segments through the meter is registered upon a counter.

Several types of positive displacement meters are in use (see box). They may be classified as:

- Oscillating Piston
- Reciprocating Piston
- Rotary

METER PROVERS

The reliability of any measurement instrument is not established until it has been checked or proved by comparing its operation against a known and established value. To this end, several methods have been devised by which meter performance may be evaluated—volumetric, gravimetric, master meter and others.

Volumetric Provers. The volumetric prover tank is the most commonly used. These tanks may be classified as: seraphin neck and wier.

The seraphin neck may be open or closed. As the name indicates, it has a reduced volume neck at the top and bottom of the tank. This smaller diameter permits

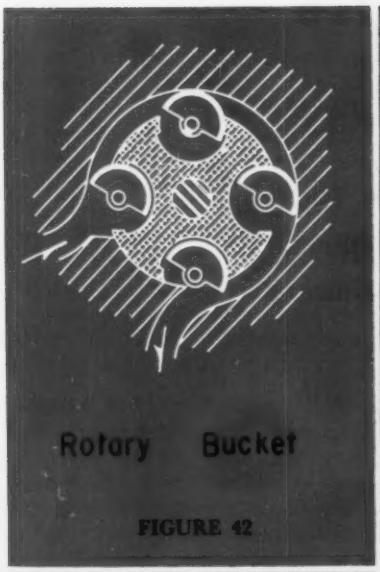
measurement to be determined with a minimum of reading error. The liquid level in the neck is visible in a gauge glass that is affixed to the seraphin neck. Additional gage glasses are provided in the body of the tank to allow observation of the fluid level in the tank.

The bottom of the tank may be of dished head or cone shaped. However, the cone-shaped bottom is preferable since deposits of sediment, valve lubricant or rust flakes are not as likely to accumulate.

A flange on the lower neck should be provided to permit inspection of the tank interior.

Angle stem immersion type thermometers are located around the tank at staggered levels so an accurate average temperature of the fluid in the tank may be determined. The depth of immersion should be at least 12 inches. The thermometer must read in single degree divisions. The thermometer should range to at least 150°, F, which is sufficient to protect it from summertime ex-

TYPICAL POSITIVE DISPLACEMENT METERS



Rotary Bucket

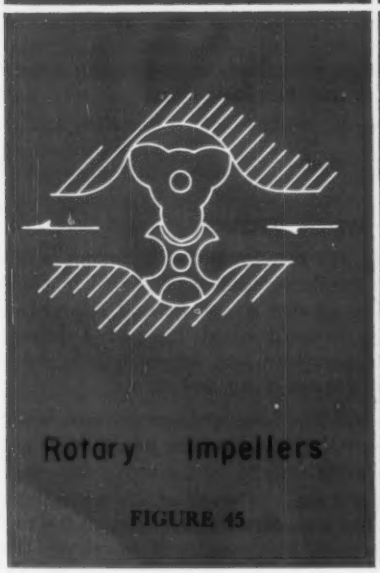
FIGURE 42

Oscillating Piston

FIGURE 43

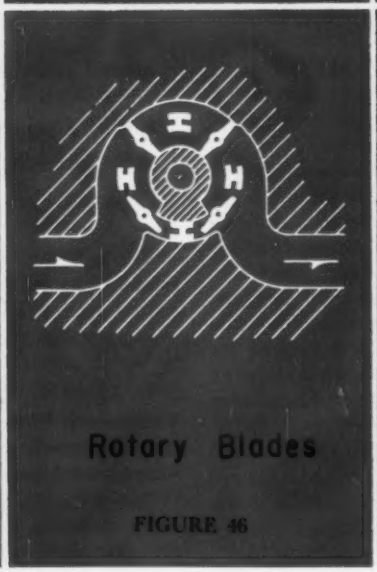
Sliding Vanes

FIGURE 44



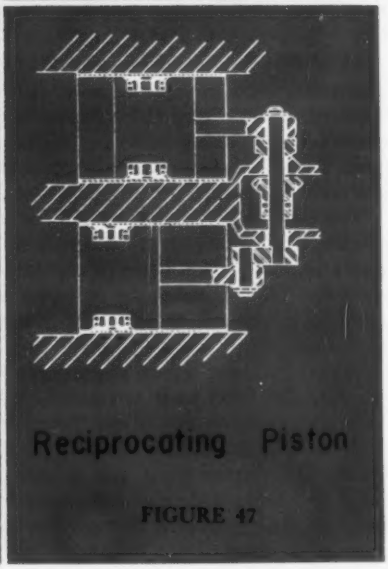
Rotary Impellers

FIGURE 45



Rotary Blades

FIGURE 46



Reciprocating Piston

FIGURE 47

posure to direct rays of the sun.

An interior coating of epoxy resin or plastic is helpful in speeding run-down of the fluid. It also deters wax accumulation and rusting.

In some cases, where the liquid is volatile or where extreme weather is encountered, the outside of the tank may be insulated to prevent temperatures from changing too rapidly.

In open-type provers, or in provers where the space above the fluid does not contain saturated vapors, a spray line should be provided so that vapor losses from the fluid will not introduce an error in the measurement.

Entrance lines to the tank should preferably enter the tank from the bottom because where entrance to the tank is from above, the formation of foam at rapid flow rates not only interferes with the reading of the prover tank, but also induces an error by allowing suspension of a portion of the liquid in the foam.

Wier Tank. The meter code specifies that the minimum prover tank volume shall not be less than the volume delivered through the meter in one minute. To minimize error in reading the tank level, it is wise to size the prover tank reasonably above this recommended minimum.

Figure 42—Rotary Bucket. This meter has a drum body, with inlet and outlet ports, separated by a baffle or dividing plate. A central cylinder is suspended concentrically inside the meter body, with a close clearance on the sides of the meter chamber and a diameter one-quarter smaller than the diameter of the meter body. The flow around the cylinder is restricted by four semi-circular buckets built into flutes in the cylinder surface. These buckets rotate about center pivots, which are fastened to the cylinder.

The buckets are gear driven from a center gear fastened to the meter body, so that they rotate about their own pivots, simultaneously with the rotation of the cylinder in which they are mounted. A close tolerance is maintained between these buckets and the meter body, which effects a seal to prevent any by-passing of liquid. As a result of the rotation of the cylinder and buckets, the liquid is trapped in the buckets or between the buckets and is, therefore, volumetrically metered. The number of revolutions of the cylinder is directly proportioned to the flow.

Very recently a design change has been made in this meter, which affects only the measuring element. The planetary gear control of the buckets has been changed to a simple crank and cam type control. The manufacturer claims lower maintenance cost, higher capacity, and greater accuracy for this change in design.

Figure 43—Oscillating Piston. This meter is generally found in the smaller sizes, in gasoline dispensing pumps, water service, lubricating oil, and chemical measurement service. In the larger sizes, up to 3 or 4-inch, it has been used in products pipe line service.

The measuring element secured in a body or case consists of only four basic parts—the top head, bottom head, cylinder and piston. The only moving part in the measuring chamber is the piston.

A division plate separates the inlet and outlet ports, and the piston glides or oscillates within the chamber, and the piston is slotted to clear the division plate. The motion of the piston is transmitted through an enclosed gear train to the meter register or counter.

Figure 44—Sliding Vane. The rotor in this rotary-type meter is fitted with sliding vanes that are moved inward and outward by a stationary cam. Fluid entering the inlet port exerts a pressure against the vane (or blade). This difference in pressure will cause the rotor to rotate. A segment of fluid of definite volume is isolated between the rotor blades. The direct passage of fluid from the inlet to the outlet is prevented by a block or divider and the rotor blade retracts to pass over the divider block. A gearing system transmits the correct values to the meter register.

Figure 45—Rotary Impeller. This is a true rotary meter, with two spiral fluted impellers. One of these lobes or impellers functions as a rotary divider. Fluid enters the spiral flutes of the rotors, causing them to rotate. An exact volume of liquid is momentarily isolated from inlet and outlet, and the passage of these segments of fluid through the meter is transmitted through gearing to the meter register. This meter is in complete static and dynamic balance.

Figure 46—Rotary Blade. This meter has a rotating element in which concentric blades pivot and the blades are positioned by a stationary cam. The dividers are a part of the rotating element. This rotor is dynamically balanced.

As segments of the fluid are progressively isolated in the measuring chamber, the rotation of the metering element is transmitted through gears to the meter register.

Figure 47—Reciprocating Piston. This type meter has been manufactured in sizes from 1 inch up through 4 inch pipe sizes. It has been used in pipe line service, but with the development of the rotary meter only the smaller sizes, through 2 inch, remain in production. Their uses at the present are confined to production measurement, bulk station or tank truck and in chemical service usage.

There are many variations in the application of pistons to the positive displacement meter. The number of pistons in these various applications range from one to as many as five. The pistons are sealed with leather, composition, or metallic piston rings, or employ the firm or capillary seal principle.

In some of these meters the fluid measuring chamber is on only one side of the piston and the thrust from the piston actuates a crankshaft or a nutating yoke, which transmits the motion to gears and to the meter register. In other cases the fluid is metered on alternate sides of the piston or pistons and the reciprocating motion is translated to rotary motion by use of ratchet action, to actuate the meter register.

The piston meter is most generally provided with slide action valves that control the fluid flow sequence to the metering chamber and circumvent the meter from stalling on dead center.

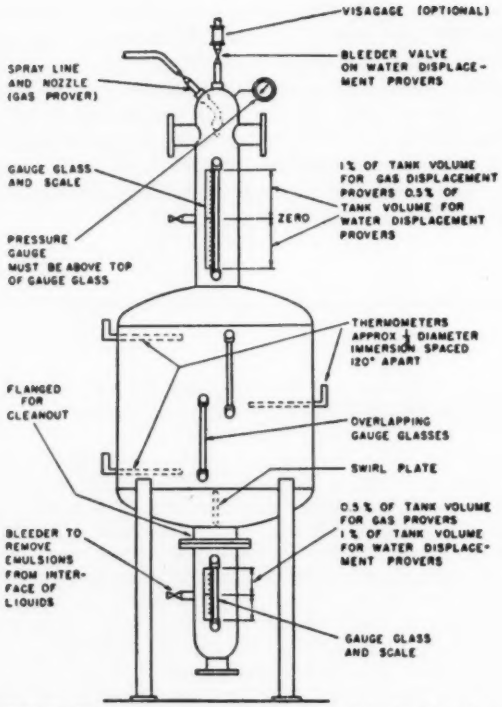

VISAGAGE (OPTIONAL)
BLEEDER VALVE ON WATER DISPLACEMENT PROVERS
SPRAY LINE AND NOZZLE (GAS PROVER)
GAUGE GLASS AND SCALE
1% OF TANK VOLUME FOR GAS DISPLACEMENT PROVERS 0.5% OF TANK VOLUME FOR WATER DISPLACEMENT PROVERS
ZERO
PRESSURE GAUGE MUST BE ABOVE TOP OF GAUGE GLASS
THERMOMETERS APPROX ¼ DIAMETER IMMERSION SPACED 120° APART
FLANGED FOR CLEANOUT
OVERLAPPING GAUGE GLASSES
SWIRL PLATE
0.5 % OF TANK VOLUME FOR GAS PROVERS 1 % OF TANK VOLUME FOR WATER DISPLACEMENT PROVERS
BLEEDER TO REMOVE EMULSIONS FROM INTERFACE OF LIQUIDS
GAUGE GLASS AND SCALE

FIGURE 48—This volumetric prover tank is the closed type.

With the development of larger capacity meters a requirement for larger capacity prover facilities became necessary. In this connection the double-wier-type prover tank was developed.

This prover (Figure 49) is based essentially on the principle of a fixed volume between two knife-edged surfaces. The double-wier-prover consists of a large cylindrical tank equipped with an overflow connected to a cylinder of reduced cross-section mounted alongside the fixed-volume section. The smaller section is graduated and connected to the fixed volume section in such a manner that the total volume run through the meter can be read accurately as the sum of the volume between the knife edges and the volume that overflows into the smaller section.

The larger vessel is equipped with 36-inch immersion type dial thermometers, and with gage glasses to allow observation of liquid level. The smaller cylinder is equipped with gage glasses and graduated scale for accurate reading of overflow.

Gravimetric Prover. The weigh tank should have sufficient capacity to hold a volume equal to one and one half times the maximum rated volume delivered per minute by the largest meter to be proved.

Two types of weigh tanks are recognized: the open type (Figure 50), which is satisfactory for liquids of low vapor pressure, and the closed type for liquids of higher vapor pressure.

The tank is mounted upon scales of conventional design, and the meter code recommends that the weigh-beam of the scale be graduated to 100 pounds by one-half pound divisions. The maximum capacity of the scale should be 20 per cent greater than the gross weight of the tank when filled with the test liquid, and including all attachments to the tank. The maximum acceptable adjustment shall be the value of one of the minimum weighbeam graduations, or an accuracy within 0.5 pounds. Connections to the tank should be made with flexible couplings.

The scale and tank assembly must be protected from wind and rain for air currents produce weighing errors several times the magnitude of the minimum graduations.

The weight-type-tank method of meter proving is particularly advantageous where liquid being metered is extremely viscous, has a tendency to deposit wax or contains suspended materials. In extremely cold climates this method is possibly the most accurate.

The disadvantage of this method is that accurate determination must be made of the specific gravity. Ac-

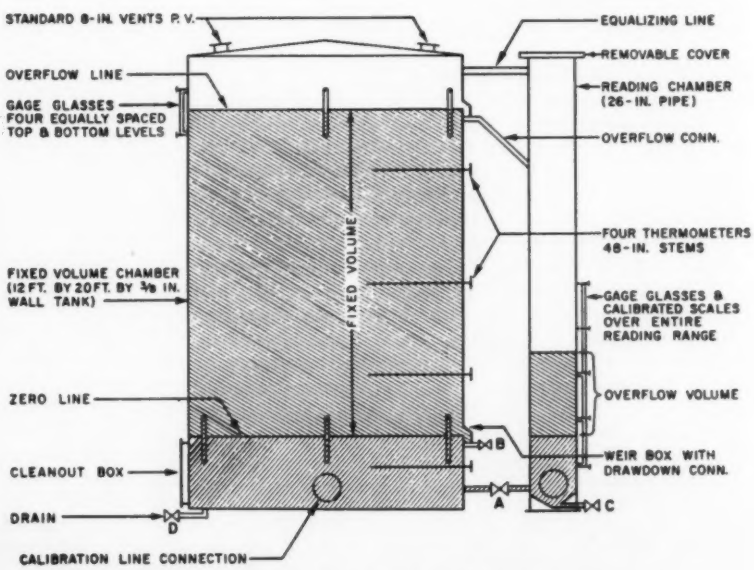


FIGURE 49—This prover tank is the double wier type.

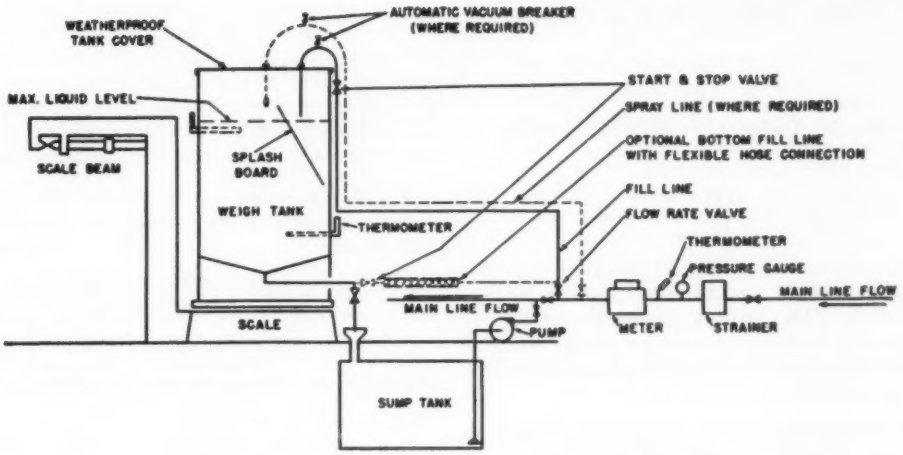


FIGURE 50—Scheme for operating the open gravimetric prover.

curacy of the order necessary must be made with laboratory precision, which is objectionable for a field operation.

Master Meter. This method involves a permanently installed meter or a portable meter that has first been tested by proving it against a prover tank.

Flow is directed through both the master meter and the second meter with which it is in series, and the accuracy of the second meter is thereby determined.

Miracle Mile. With this method of meter proving, a section of pipe line is calibrated and a "pig" or pipe line scraper of special design is run between points in this line and at these points an electric switch is actuated, tripping a solenoid which operates a dual meter register. The meter volume is compared against the pipe line displaced between the contact points, corrected for temperature, to establish the meter accuracy.

Removable Unit. Meters equipped with removable measuring chambers or mechanisms as a unit may have these units removed from the meter case and installed in a test case for proving at a testing laboratory, a precalibrated unit being installed in the case after the removal of original unit for proving. (API Code 1101, Sec. V, Paragraph 5027)

CALIBRATION OF METER PROVERS

Meter measurement is expressed and regulated in terms of comparison with the prover. Therefore, the volume of the prover must be very carefully determined before it is used as standard of measurement. Obviously, the accuracy of a meter can be no more exact than the basic accuracy of its prover facility.

Detailed instructions for calibration of provers may be found in Section II of the Positive Displacement Meter Code.

The primary standard for the calibration of prover tanks is the five-gallon test measure (Figure 51). The volume of this measure must be established and certified by the National Bureau of Standards in Washington, D. C., to contain five U.S. Standard gallons at 60 degrees F, and must therefore be wiped dry after each measurement.

A one-gallon measure is very useful and must be certified by the National Bureau of Standards.

To facilitate calibration of large prover tanks, it is desirable to use measures larger than the five gallon primary test measure. Measures larger than five gallons are classified as secondary measures and are calibrated to deliver at 60° F, using the five-gallon primary and the one-gallon supplementary test measures, or it may be sent to the National Bureau of Standards for calibration. Measuring cans certified to deliver must be wetted at the start of the test.

TEMPERATURE CORRECTION

A common property of oil is the change of volume with changes of temperature. A barrel of oil will expand when the temperature increases and shrinks when the temperature decreases. For this reason the petroleum industry has agreed that in buying or selling oil that a barrel shall be standard at a base temperature of 60° F.

In general, the increase in the volume of a given amount of liquid will be directly proportional to the increase of its temperature. All liquids do not, however, expand at the same rate. For example, 60° API gasoline will show an increase of 1.28 gallons in 100 gallons, for a temperature increase of 20° F. On the other hand, 10° API crude oil for the same temperature rise would be only 0.72 gallons. The measure of this expansion is termed the coefficient of expansion, for the particular liquid being considered.

The coefficient of expansion of a liquid is the fractional part of the original volume by which the original volume will be increased when the temperature is increased by 1° F. In the case of the gasoline above, the increase for 20° F temperature increase is 1.28 gallons. The increase for 1° F, expressed as a fractional part of

the original volume of 100 gallons is 0.064/100 or 0/00064. Hence, the coefficient of 60° API gasoline is 0.00064.

Or, $$\frac{1.28 \div 20}{100} = \frac{0.064}{100} = 0.00064$$

If the temperature of this 60° API gasoline increased 1° to 61° F, the original volume would expand by the amount of 0.00064. The increase in volume would be 1 + 0.00064 or 1.00064. To arrive at the correct volume at 60° F, the volume at 61° F should be multiplied by the factor 0.99936.

Conversely, should the temperature have decreased 1° to 59° F, the original volume will have decreased 0.00064, so the decrease in volume would be 1 — 0.00064 or 0.99936. To arrive at the corect volume at 60° F, then, the volume at 50° F should be multiplied by the factor 1.00064.

ASTM Table No. 62 is an unabridged table commonly used in meter proving procedure, that contains factors for correcting volumes of petroleum observed at temperatures other than 60° F to the corrected volume at 60° F. Gravity range of this table is from 0° API to 100° API in temperature ranges considerably above and below those required for pipe line measurement purposes.

ASTM, Table No. 7 is an abridgement (of Table No. 6) generally used in the industry for correction of crude oil volumes.

Grouping in ASTM Table No. 7 is as follows:

Group No.	Co-efficient of Expansion Per Degree F.	Gravity Degrees API	API Gravity Range of Each Group
0	0.00035	..	up to 14.9
1	0.00040	22	15.0 to 34.9
2	0.00050	44	35.0 to 50.9
3	0.00060	58	51.0 to 63.9
4	0.00070	72	64.0 to 78.9
5	0.00080	86	79.0 to 88.9
6	0.00085	91	89.0 to 93.9
7	0.00090	97	94.0 to 100.0

Application of factors from the tables shorten and simplify the calculation in reducing a volume to the 60° F base, and yields greater accuracy.

(1) For example, a tank contains 12,000.00 barrels of 42 gravity oil at 82° F. From Table 7—Group 2, oil has a coefficient of expansion of 0.00050.

Then 82° — 60° = 22° F × 12,000.00 × 0.0005 = 132.00, 12,000.00 — 132.00 = 11,868.00 net barrels @ 60° F.

(2) The same calculation using the more accurate Table 6: 42° API oil at 82° F observed temperature—factor = 0.9893, 12,000.00 × 0.9893 = 11,871.60 net barrels @ 60° F.

ASTM Table 24 is used where oils whose API gravity at 60° F is above 100°. ASTM Table 5 is used to convert gravities at observed temperatures to the 60° F base.

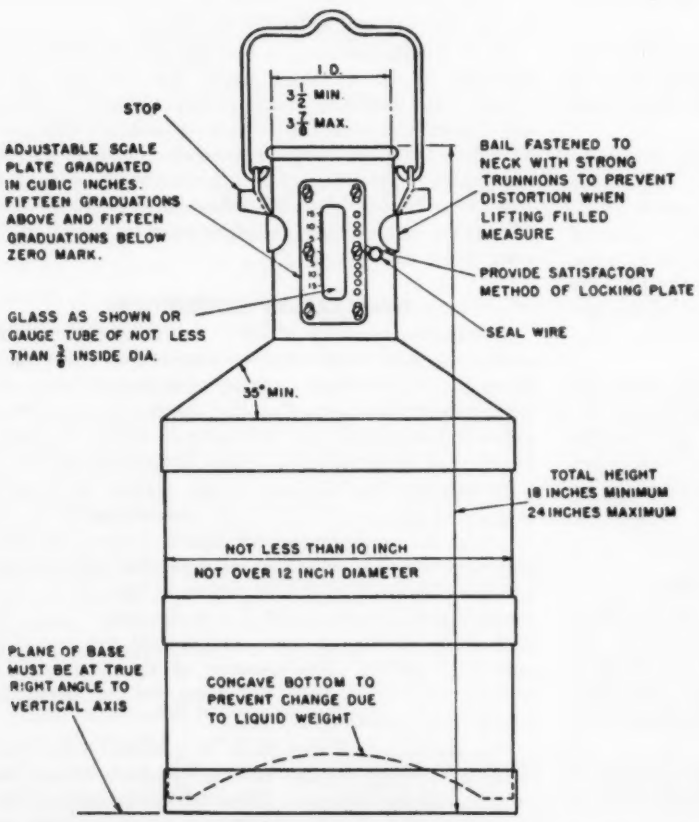

I.D.
3½ MIN.
3⅞ MAX.
STOP
ADJUSTABLE SCALE PLATE GRADUATED IN CUBIC INCHES. FIFTEEN GRADUATIONS ABOVE AND FIFTEEN GRADUATIONS BELOW ZERO MARK.
GLASS AS SHOWN OR GAUGE TUBE OF NOT LESS THAN ⅜ INSIDE DIA.
35° MIN.
BAIL FASTENED TO NECK WITH STRONG TRUNNIONS TO PREVENT DISTORTION WHEN LIFTING FILLED MEASURE
PROVIDE SATISFACTORY METHOD OF LOCKING PLATE
SEAL WIRE
TOTAL HEIGHT 18 INCHES MINIMUM 24 INCHES MAXIMUM
NOT LESS THAN 10 INCH
NOT OVER 12 INCH DIAMETER
PLANE OF BASE MUST BE AT TRUE RIGHT ANGLE TO VERTICAL AXIS
CONCAVE BOTTOM TO PREVENT CHANGE DUE TO LIQUID WEIGHT

FIGURE 51—This five-gallon test measure is the primary standard for calibrating prover tanks.

GRAVITY DETERMINATION

From observing the relationship between gravity and the coefficients of expansion of petroleum, it is evident that the gravity determination of oil is a very important factor in the final determination of volume. Also, the misreading of the hydrometer or thermometer in making a gravity determination may cause a difference in the price paid for some oils.

In gravity determination made on butane, propane, and natural gasoline mixtures, determination may be made with a hydrometer until reaching 90 degrees API.

From 90 degrees API upward, a closed container should be used, and the specific gravity of the product determined by other methods. Specific gravity is then converted to degrees API. ASTM procedure for highly volatile, lighter than 70° API mixtures, specifies that the gravity sample be cooled to 35° F or lower in the original container, if open cylinder and hydrometer are used.

Determination of the gravity of the metered petroleum or petroleum product, before proving a meter, is very important. An error in this determination may cause an appreciable error to be introduced into meter proving results.

COMPRESSIBILITY CORRECTION

Because of the variation in the compressibility of liquids, meter accuracy changes when operating a meter at pressures considerably at variance with the pressure under which the meter was proved. The need for correction is recognized and is determined by the accuracy sought in the individual operation. The magnitude of the compressibility of the fluid being metered can be determined from Figure 52 (API PD Meter Code, Paragraph 5043, Section V. See also Section III, Paragraph 3027, 3028 and 3029.).

The correction factor to the meter factor, C_{pc}, is obtained as:

$$C_{pc} = 1 + (P_{mo} - P_{mc})\ (F_2).$$

Where:

C_{pc} = Correction factor by which it is necessary to multiply the meter factor to account for an operating pressure within the meter case which is different from the case pressure during the proving runs.

P_{mo} = Pressure in psi gage at which the meter is operating.

P_{mc} = Pressure in psi gage at which the meter was proved.

F_2 = Apparent compressibility factor per psi for the liquid being metered at the temperature at which it is passing through the meter.

GASOLINE MIXTURES

In metering gasoline mixtures, problems are encountered which do not present themselves in measurement of the more stable petroleum fluids. Butane and propane are on the border line between liquid and gas; they are gases under normal conditions, but are readily condensible to liquid under proper conditions of temperature and pressure.

At atmospheric pressure butane will remain in liquid state if the temperature is kept at a point slightly below freezing, or about 31° F. Propane will remain a liquid at atmospheric pressure if the temperature is kept below 44° below zero Fahrenheit. These terms are useful to describe properties of fluids:

Critical Temperature—the temperature above which the the hydrocarbon gases cannot be liquefied, no matter how much pressure is applied.

OPERATING HINTS

1. Meter factors generally do not change over 1 percent during a month of operation.
2. A meter that has been proven and returned to its location to serve as a spare may rust after three weeks or go off calibration for some other reason. So, by switching meters each sampling period (usually eight days or less), the meters maintain better accuracy and require less maintenance.
3. After a meter has been taken off the line, it should not be left for several days before proving. If it is taken out of the line and removed to a shop for subsequent proving, it should be filled or coated with a light machine oil for protection during this idle and exposed period.
4. After a meter has been repaired and calibrated, it should be filled with light machine oil until it is returned to its station and made ready for in-line service.
5. Positive displacement type meters used in light hydrocarbon service should be derated to 75 percent of the manufacturer's stated maximum capacity to give more accurate measurement and to reduce repair and maintenance costs.
6. Meters should never be run for more than one month without being calibrated, except in emergencies when the standby meter has unexpectedly failed in service.

Critical Pressure—the pressure required to liquefy a hydrocarbon gas at its critical temperature.

Vapor Pressure—the pressure exerted by the activity of the molecules. It is the tendency of a liquid to evaporate. Usually it's obtained from the ASTM Reid vapor pressure test. In this test the sample is enclosed in a bomb with a gauge to indicate pressure. The test is carried out under specified conditions, the bomb being immersed in a water bath whose temperature is carefully maintained at 100° F.

Absolute Pressure—gage pressure plus atmospheric pressure. The weight of the atmosphere exerts a pressure of 14.7 psia on the surface of the earth at sea level.

Temperature (F.) to Liquefy at Atmospheric Pressure

Compound	Degrees API	Critical Temp. (Deg. F.)	Critical Pressure (PSIA)	Temp. to Liquefy At Atmos. Pressure (Deg. F.)	Vapor Pressure 100° F PSIA
Methane CH_4	....	—116.5	673	—258.5	.....
Ethane C_2H_6	....	90.1	708	—128.2	.....
Propane C_3H_8	147	206.3	617	— 43.8	189.5
Iso-Butane C_4H_{10}	119.8	275.0	529	10.9	73.5
N-Butane C_4H_{10}	110.8	305.6	551	31.1	52.0
Iso Pentane C_5H_{12}	94.9	370.0	483	82.2	20.3
N-Pentane C_5H_{12}	92.7	385.9	489	97.0	15.5
N-Hexane C_6H_{14}	81.6	454.5	440	155.7	5.0
N-Heptane C_7H_{16}	74.2	512.6	397	209.1	1.63
N-Octane C_8H_{18}	68.6	565.2	362	258.1	0.54
N-Nonane C_9H_{20}	64.5	.....	...	303.3	0.19
N-Decane $C_{10}H_{22}$	61.3	.....	...	345.2	0.06

In proving a meter in natural gasoline, butane and propane service, pressures and temperatures are very important. If temperature of the metered fluid is relatively high, (100° F

or higher) a decrease in back pressure maintained on the prover tank will cause lighter fractions of the fluid to flash or to be evolved as free gas. Likewise, if back pressure maintained on the meter drops too low, gas will be evolved in the meter, causing the meter to give incorrect registration. This evolved gas cannot be returned to liquid stage by simple reapplication of pressure. If flashing of gasoline mixtures is observed in the gauge glasses of a prover tank, you may be certain that the results of the meter test will not be correct.

METER BREAK-IN

Meters have a wearing-in period when first installed and during that period the characteristics curve is somewhat unstable. For this reason it is advisable to make periodic provings during this wearing-in operation until the meter factor becomes relatively stable. This procedure should also be followed after any major adjustment, after repairs have been made or after any change has been made in meter parts.

AUXILIARY EQUIPMENT

The operator should make sure he understands the auxiliary equipment that makes accurate metering possible. This equipment includes: plug valves, air eliminators, strainers, rate valves, set stop valves and ticket printers.

Valves. For meter installations, they should be plug valves or valves that do not displace fluid when operated. Types of plug valves that rise from their seat in operation, and displace fluid should not be used. The valve should be one that may be used to throttle or adjust the fluid stream and should be a valve that can be closed both smoothly and quickly.

Air or Vapor Eliminators. These should be provided ahead of the meter where there is a possibility of air, gas, or vapors entering the meter. Such as in field gathering systems, where tank trucks are unloaded and on receipts from tankage not under company control. Gas passing through a meter will register exactly the same as liquid, and represents loss to the pipe line (over-registration).

Strainers. A vertical type strainer should be installed close to the meter, to prevent dirt and foreign particles from entering the meter where they might cause considerable damage. It should be located where it is readily accessible, and should be inspected and cleaned regularly. The mesh should be suited to the meter service. Fine mesh on non-viscous liquids and ⅛" hardware mesh on viscous fluids.

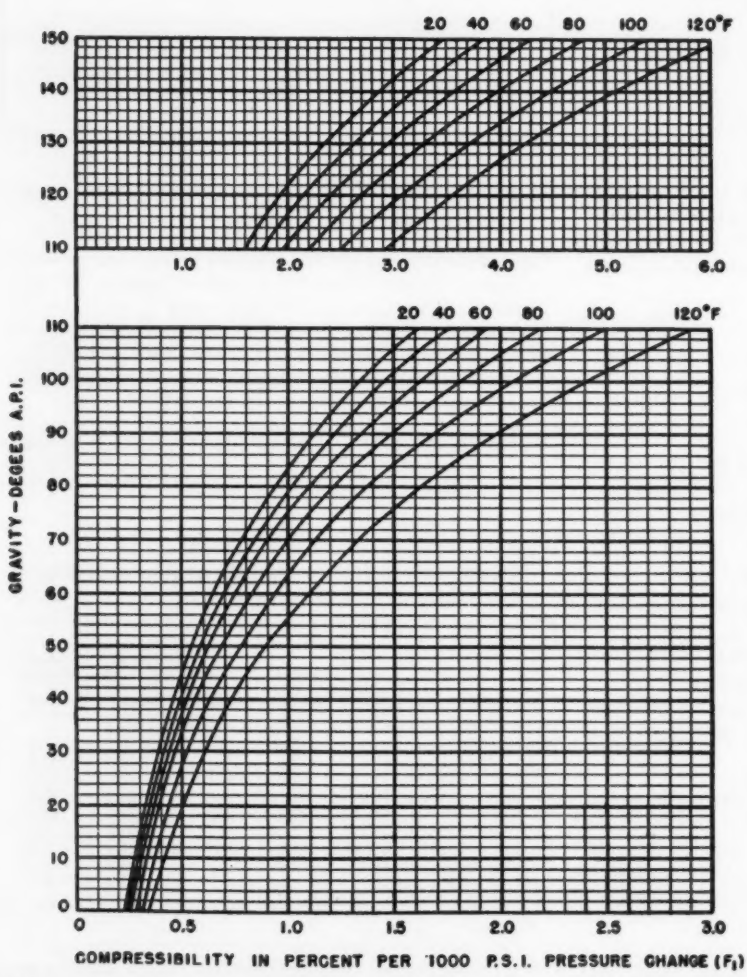


FIGURE 52—Compressibility of liquid hydrocarbons based on data from 0 to 1,000 psig.

Rate Valves. When several meters are in an operating bank, or when a meter is receiving from a tank truck it may be necessary to use a rate-of-flow valve to prevent the meter from running at excessive speeds.

Set Stop or Quantity Control Valves. Where receipt or delivery of a predetermined amount of fluid is to be measured, the set stop valve operates from a reverse-acting counter, closing a valve when the predetermined volume has been metered. Useful in lease metering operations to prevent "over-running" of oil tenders and for predetermined loading of transport trucks are characteristic functions of the quantity control valves.

Ticket Printers and Large Numeral Counter. Some meters are equipped with ticket printers and large numeral counters. The ticket must be placed in the printer before the meter is in operation. A crank is turned and the opening reading is printed. Meter is then put into operation. At the close of the delivery, the meter must be stopped before the closing meter reading is printed, by turning the printer crank. After the starting reading has been stamped on the ticket, a pin enters and holds the ticket firmly in place. After the closing reading has been printed, the ticket may be removed with ease. Printing an opening or closing reading while the meter is in operation will overload the gearing system and usually result in a sheared gear pin.

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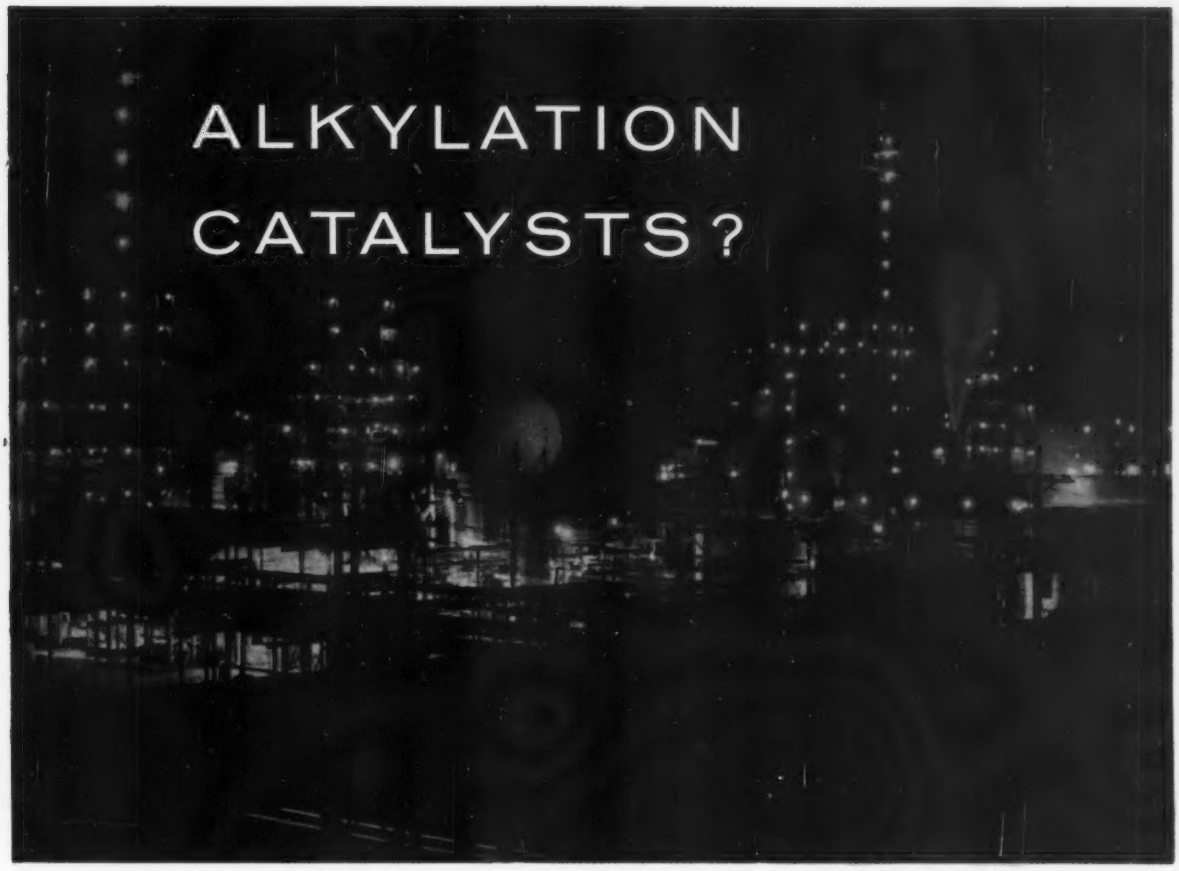
[2] ASTM-IP Petroleum Measurement Tables. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. 1952.



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(Jacobs, M. B., *The Chemical Analysis of Air Pollutants,* Interscience Publishers, Inc., 430 pages, $13.50. For sale by Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas.)

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- Organization Charts.
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- Trouble-shooting charts.
- Photos, circuit diagrams and other illustrations.
- Principles of operation.
- Complete calibration instructions.

(Carroll, G. C., *Industrial Instrument Servicing Handbook,* McGraw-Hill Book Co., $16. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

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(Horn, Milton B., *Acrylic Resins,* Reinhold Publishing Corp., 184 pages, $4.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

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- Fluid flow through fixed beds, and all important correlations.
- Available data on bubble velocity and bubble size in fluidized beds.
- A generalized correlation for calculating the rate of entrainment of solids from fluidized beds for any particle size and distribution, superficial fluid velocity, and height above the bed.

(Zenz, F. A., and Othmer, D. F., *Fluidization and Fluid-Particle Systems,* Reinhold Publishing Corp., 513 pages, $15. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

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"American Standard Safety Code for Head, Eye, and Respiratory Protection" provides reasonable and adequate means, ways, and methods for the proper selection and safe use of head, face, neck, eye, and respiratory protective equipment. It applies to all operations or processes except those relating to communicable airborne diseases or x-rays, gamma rays, and high-energy particulate radiation such as alpha, beta, or neutron rays.

Changes made since the previous 1938 edition include the addition of plastic eye protectors, and an increase in strength requirements for eye protection. One section contains 86 definitions of words common to this field. In general, the code has been brought up-to-date with modern production methods working environments and available safety equipment.

(*ASA, American Standard Safety Code for Head, Eye, and Respiratory Protection,* American Standards Association, 70 E. 45th St., New York 17, N. Y., 46 pages, $3.)

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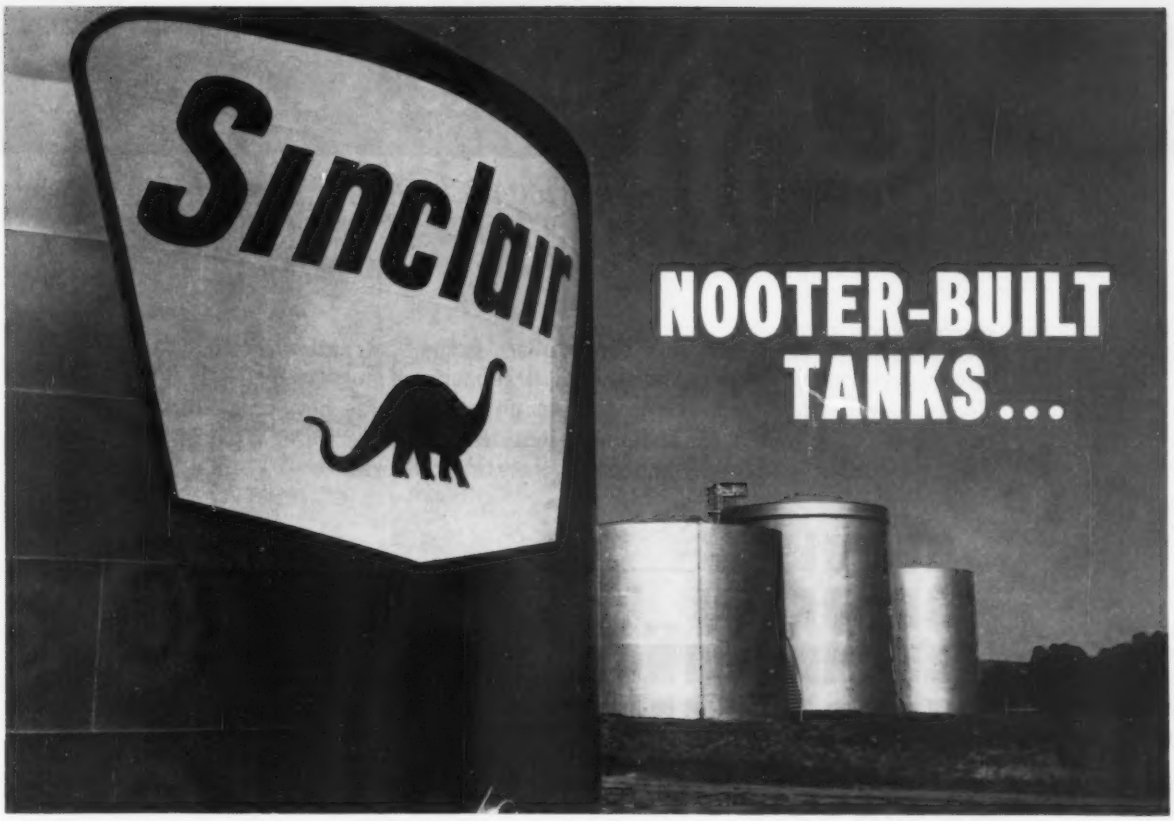
- Part 2, Non-Ferrous Metals Specifications and Electronic Materials, 280 pages. Includes 38 standards for copper and copper-base alloys, ingot, plate, sheet, strip, rolled bar, shapes, wire, die forgings, pipe and tubes. Also tin, nickel alloys, titanium, materials for electron tubes and semiconductor devices, metal powders and electrodeposited metallic coatings. In addition there are standards for die-cast metals, aluminum and aluminum alloys, magnesium and magnesium alloys, and metallic electrical conductors.

- Part 7, Petroleum Products, Lubricants, Tank Measurement, Engine Tests, 428 pages. Includes 43 standards for liquefied petroleum gases, motor and aviation fuels, solvents and naphthas, diesel fuels, engine lubricating oils, industrial oils, turbine oils, electrical insulating oils, greases, spray oils, bituminous materials. In addition there are engine test methods for rating fuels, tank measurements and sampling standards.

Titles of other parts are: Part 3, Methods of Testing Materials (Except Chemical Analysis) 110 pages; Part 4, Cement, Concrete, Mortars, Road Materials, Waterproofing, Soils, 200 pages; Part 5, Masonry Products, Ceramics, Thermal Insulation, Acoustical Materials, Sandwich and Building Constructions, Fire Tests, 218 pages; Part 6, Wood, Paper, Shipping Containers, Adhesives, Cellulose, Leather, Casein, 142 pages; Part 8, Paint, Naval Stores, Aromatic Hydrocarbons, Gaseous Fuels, Engine Antifreezes, 252 pages; Part 9, Plastics, Electrical Insulation, Rubber, Carbon Black, 546 pages; Part 10, Textiles, Soap, Water, Atmospheric Analysis, Wax Polishes, 394 pages.

(ASTM, *The 1959 Supplements, 1958 Book of ASTM Standards,* American Society of Testing Materials, 1916 Race St., Philadelphia 3, Pa., $4 per Part, $40 for all 10 Parts.)



...added to Sinclair terminals on the Laurel pipe line

Sketch of Additional Tanks built by Nooter at Sinclair Terminals

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what's your best estimate?

. . . a quiz for refinery men who want to keep posted

QUESTION 1. At the close of World War II, the vast nation of India had two petroleum refineries with a total capacity of only 10,000 B/D. Today, one of these original production units and three new ones are turning out oil products for India at a considerably greater rate. What is the total crude capacity of India's four operating refineries?

a ▮▮▮▮▮ 43,000 B/D

b ▮▮▮▮▮▮▮▮ 76,000 B/D

c ▮▮▮▮▮▮▮▮▮▮▮ 107,000 B/D

d ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮ 144,000 B/D

QUESTION 2. What per cent of India's present refining capacity has been designed, engineered and constructed by Lummus?

a % % % % 39%

b % % % % % % 63%

c % % % % % % % % % 91%

ANSWERS*: 1. *(c)—or 107,000 B/D—is the right answer.*

2. *(c) again—or 91⅞ is correct. Lummus has built all three of India's postwar refineries, with a combined capacity of 97,500 B/D, through The Lummus Company Ltd. of London. Lummus Ltd.'s organization maintains a staff of over 400 specialists, and has engineered and constructed hundreds of process plants of all types and sizes, from India to Ireland. Lummus Ltd. is one of several international members of the Lummus group of companies which circles the globe. See Lummus on your next project.*

**Statistics according to World Petroleum.*

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GROUP DYNAMICS IN DECISION MAKING

How does management make decisions and place them into operation? Usually it's through edicts under an authority-obedience power system. But there is a much better way—as you will learn from this interesting and informative new series

Robert R. Blake and Jane S. Mouton
The University of Texas, Austin

WHAT IS a refinery? First and foremost, it's a city of pipe—miles and miles of pipe and in between the pipe, it's cat crackers, compressors, valves, ventilators, stills and storage tanks. Crude in one end, refined products out the other—modern chemistry and engineering designed to change raw materials into useful products at a profit.

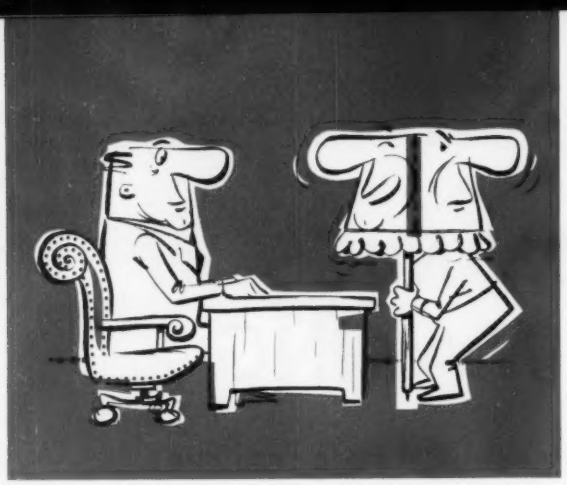
Yet a refinery is more than that, much more. It's people—people who work alone, or in pairs, or in groups, or as group members joining with members of other groups searching for solutions to common problems. Its work programs are made of people who fit pipe, weld, or paint; who wash down an area, decide on turnarounds, plant modifications—thruput volume, conduct research, or run control checks. Some of these people are high in rank—they establish policies which influence the lives and activities of many others. Some are technically trained—they influence situations that are difficult for others to understand. Some are analysts and forecasters. Some are practical men with years of applied knowhow behind them. Some are operators; some laborers. Some are completely loyal to management, some to the union, some are loyal to both.

Planners, pipe-fitters, pipe, petroleum, and refined products all have to fit together in an integrated way before a refinery is a producing organization. Decisions determine how the operation shapes up, and in the final analysis it's people who make the decisions as to how to fit things together in the most effective manner. Sound decisions produce effective results, as measured by products, profits, and the contributions people make to work. Poor decisions lead to trouble.

Making Better Decisions. The central question is, "How can the decision-making skills of a refinery be improved?" A 10, or even a 5 percent improvement would make a great deal of difference in the total effectiveness of any organization. How can the batting average for over-all decision-making efficiency of any organization—refinery or headquarters—be improved, be brought closer to maximum?

The key rests with each manager. For to be successful, a manager must be an applied human scientist who approaches situations and designs solutions to problems according to systematic principles, rather than on impulse, by rules-of-thumb, or purely on the basis of tradition or convention. Thus only by learning to solve problems with sensitivity and skill will a shift from present day fire-fighting be possible, and plenty of fire-fighting is going on right now. Failures even at the fire-fighting level can be seen in strikes; in absenteeism disguised as illness; in chronic, deep-lying conflict between technical and practical people and in foremen feeling isolated from management on one side and from the work force on the other. Only by a shift towards coping with and correcting the real underlying causes of these problems will genuine industrial progress be possible.

The ideas that can make the difference between an industrial fire-fighter and an applied human scientist of management are as available as the library on any college campus. But a manager can't get someone to tell him how to use them—as a manager he has to become a more skillful applied human scientist himself. How can it be done? Through *applied group dynamics* which will be described in this series of articles. This laboratory for management development is an approach which holds much promise for the manager who wants to learn to translate social ideas into practical application for improving the operation of the human side of refining.



I am now able to express my feelings—according to the situation

EFFECTIVE DECISION-MAKING

Let's first examine two central areas of human interaction that can make the difference between sound decisions and ones that don't stand up against operating requirements. It is in these areas that social science knowledge offers much to the modern manager.

Two words strike at the heart of the issue of getting improved decisions. One is *participation*. The other is *communication*. Both are overworked—neither is too well understood. Participation, for example, is a great deal more than just being there, or "Giving someone else's decision a vote of confidence," or thinking, "No" and saying, "Yes." Communication is much more than passing information down the line, or saying "Good Morning!" or checking on whether a job is going according to schedule. Both words take on new meaning and lead to much improved behavior when the *processes* of participation and of communication as they affect decision-making are examined under the microscope.

What do these words mean in the setting of a management development laboratory? Let's listen first to what people say about participation, communication, and decision-making after studying group dynamics in a management development laboratory. Then we can examine a laboratory design in more detail to see why these words take on new meanings, improved actions, and result in more effective decision-making.

Typical remarks after such a laboratory tell what people mean by participation and communication as these terms relate to their own decision-making.

Communication. "I hear better. I'm doing a better job of keeping my boss informed and of getting my ideas moving up where they can have a significant effect. It's much better to be able to talk with your boss and get results than to talk with your buddies and simply gripe."

"I feel more free to express my thoughts to others even when it means going against them. I can say 'yes' without being a 'yes man' and say 'no' without being a blocker."

"I do a better job in meetings than I did before. They used to be a matter of formality. Now our meetings are going a little slower, but we're accomplishing more, and we're dealing with really basic issues."

"I see the friction between process and mechanical, between the company and the union, and between staff and line quite differently than before my laboratory experience. I've been able to do a few things to reduce the gaps that separate these groups."

Participation. "Now I'm developing performance goals with my people. Before, I used to sit down and tell them what their goals should be and then criticize them if they failed to get to the goals I thought important."

"By sharing my problems with others, rather than trying to decide everything by myself, I find the problems don't belong to me alone. We have much more responsibility up and down the line than we used to. The number of decisions I make is down by 30 percent, and the amount of follow-up I have to do is down by 40. That means my job is a lot different and a good deal more pleasant."

"I've finally learned to get the practical people to check over construction and modification plans with the technical people *before* we start a job. It makes a world of difference when the engineers and the practical people work together. Practical men learn new ideas from the technical people, but the technical people discover a lot of applied wisdom that never came from textbooks. You know, a lot of valuable stuff is stored in the minds of the practical men, and we haven't been tapping it."

As a group, top level people say, "Foremen possess a richness of talent and human wisdom that we need to employ much more fully than we've been doing in the past." Foremen say, "We're better able to understand the kinds of problems those boys in the front office are faced with."

New Meanings. Here, then, are some of the new meanings people give to terms like "participation" and "communication" and "decision-making" after studying group dynamics in a management development laboratory. By comparison with ordinary meanings, people are not thinking of the company organ or of an information conference as ways to improve communications. They are asking, "How can I, myself, talk better with the people I meet and work with face-to-face?" They are not saying, "We need to increase participation around here." They are saying, "How can I share my responsibilities with others so that they want to take part and to put their opinions and actions to the solution of common problems?"

The foremen are not saying, "The people in the main office building only get out into the yard in the springtime, or when there's trouble brewing." They are saying, "He had an idea he wanted to run through the wringer. He needed some practical reactions before going further."

Top level people are saying, "The foremen know the score on this matter. Let's ask them to help with the answer."

In a nutshell it's the flavor of thinking about the human side of the enterprise that makes a management development laboratory different from ordinary communications or decision-making courses. Applied group dynamics leads to a revised theory of management. But before going further into details, let's consider briefly what there is about modern refinery management that has brought into focus programs which center management development squarely on human aspects.

THEORIES OF MANAGEMENT

A critical aspect of managerial responsibility is to develop and to continually improve a system for effective decision-making. Where decisions break down under the impact of resistance and resentment and have to be repealed, modified, or shelved, it is an indication that the management methods employed were inappropriate or were inadequately applied.

Authority-Obedience Power System. How does management go about making and placing into operation vital decisions that affect the refinery? Usually it is by following the traditional approach—through directives and edicts under an authority-obedience power system. It begins when a manager, management committee, division head, or department official spots a needed change. Then through some kind of group action some people get together, usually in private, and secretly debate the problem. A design for change emerges. When the design is finished—all tied together with a pretty bow—it is released over the signature of the president, or the general manager, or the division head, or the department head. Relief! It's done! A policy level decision has been made.

Directives achieve change, no doubt about that. However, they may also generate an experience of arbitrariness in those on whom the change is perpetrated. Arbitrariness is a mighty dangerous reaction to any situation, particularly where participation, clear communication and lowering the level of decision-making into an organization have begun to be recognized as necessary steps in effective management rather than as luxuries. Arbitrariness means that collaboration has broken down and that conditions of trust and mutual confidence have been violated. Reactions to changes introduced under conditions of arbitrariness are not too difficult to predict.

The failures of management to solve fundamental problems of operation are numerous. Featherbedding, narrow craft-line specialization, unattractive shift work, poor maintenance, low quality control, strikes, absenteeism and endless griping are typical. They are so common we have come to take them as inevitable. Yet, all of them stand as testimony to modern management's inadequacies.

Industrial legislation, unionization which specifies conditions of work and of firing, social security which offers economic protection, and other factors have resulted in the conditions which formerly made it possible to elicit cooperation based on authority-obedience being unavailable today. Yet, managers seem more secure with authority-obedience systems than with other systems of cooperation.

In spite of new conditions, blind allegiance to outmoded concepts of authority-obedience remains the basis for rigid thinking about chain of command, span of control, formal delegation of responsibility and so on. These things tend to keep managers and workers separated and to insure that information required for sound decision-making won't be available when needed. A result is that the system tends to become "mechanical," with people doing what the rules require, not what they know is needed. The product is a system of cooperation perforated with pitfalls.

About the Authors

Dr. Robert R. Blake is a professor at The University of Texas where he does teaching and research concerned with industrial social psychology in the field of management development through applied group dynamics. Dr. Blake received his B.A. degree from Berea College in 1940, his M.A. degree a year later from the University of Virginia and his Ph.D. degree in 1947 from The University of Texas. After receiving his Ph.D. Dr. Blake remained at The University of Texas, and in 1949 journeyed to England for a year where he was lecturer at the University of Reading and honorary clinical psychologist, Travistock Clinic, London. Then in 1950 he spent a year as lecturer and research associate at Harvard. Listed in *American Men of Science,* Dr. Blake is presently a director of the Policy Planning Board of the Human Relations Training Laboratory; on the Board of Trustees of the Institute of General Semantics; a member of the National Training Laboratories, American Psychological Association, Association for the Advancement of Science and many other professional societies. He is also a management consultant in industrial social psychology to many major oil and chemical companies.

Dr. Jane S. Mouton is an assistant professor at The University of Texas where she does teaching and research in social psychology basic to industry. Dr. Mouton received her M.S. degree from The University of Texas in 1950 with a major in mathematics and physics; her M.S. degree in 1951 from Florida State University and her Ph.D. degree in social psychology in 1957 from The University of Texas. Since that time she has been assistant professor, instructor and social science research associate. Dr. Mouton is a member of the American Psychological Association, American Society of Group Psychotherapy and Psychodrama, Interamerican Society of Psychology and many other professional and fraternal societies.

Modified Authority-Obedience. In exploring these problems in refineries, as well as in other production centers, it has been found that a lot of managerial thinking springs from experience with authority-obedience systems. One widely held belief is, you must choose between being hard and soft. If you're soft with your people, they are happy but you don't get much work. If you are tough, they turn out the work but become resentful, alienated and hostile towards you specifically, and towards the organization in general. Cracking down to get efficiency and then easing up to restore confidence that management means well is the pendulum theory of management; swinging from hard to soft to hard again.

Authority-obedience thinking also leads to a middle-of-the-road theory, "Don't put too much emphasis on human satisfactions and don't push too hard for productivity." As if satisfaction and productivity must always be opposite sides of a coin, rather than compatible and mutually supportive.

A third is the replacement theory. If subordinates can't get the job done, replace them with some who can.

Continued on Page 260

You Can Create a 'Professional Spirit'

Management will do well to remember that engineering is a profession— and to get the most of an engineer's ability, he must be treated as a professional

W. A. Cunningham
The University of Texas
Austin

DURING THE past decade, much effort has been expended in attempts to secure optimum utilization of technical personnel* Great stress has been laid on such items as organization and planning of engineering work, on proper training and indoctrination, and on the use of supporting personnel. However, many other factors, some of these rather intangible, contribute to productivity.

"A professional person is an individual who, with adequate training, experience, intellectual capacity, and moral integrity, effectively devotes his skills and knowledge to the service of society and his profession in whatever assignment he finds himself, being fully sensible of the professional responsibility and trusteeship conferred by his special training."

This is the opening paragraph of a statement made a few years ago by the Council, American Institute of Chemical Engineers.[1]

The engineer, as an individual member of a profession, can reach high levels and his company can best utilize his ability only when there is mutual understanding of their respective responsibilities. Quoting again from the same reference,

"The enhancement of the status of the engineer is best promoted by his reliance upon his personal professional growth and accomplishment, and his status as a professional man is endangered by reliance upon group efforts to act on his behalf in reaching short-range economic objectives. At the same time, a corresponding obligation is laid upon the employer of engineers to give each professional employe his due individual recognition as a member of the profession."

A Need. Engineers are employed because of a need (both at present and in the future) for professional people who can think and plan, and not merely for their manipulative ability, however skillful and valuable that may be. As such they are a part of management and unless that role is recognized by all parties, optimum use of the abilities of technical personnel is impossible. The uncertain, the disgruntled, the misplaced, the uninformed engineer is a liability rather than an asset.

The technical and scientific developments of the past decade have increased the complexities of operation and of management in process industries. These same developments, if properly recognized, can increase the output of all technical employes if, and only if, the inherent responsibilities of both the individual engineer and the employer are fully understood.

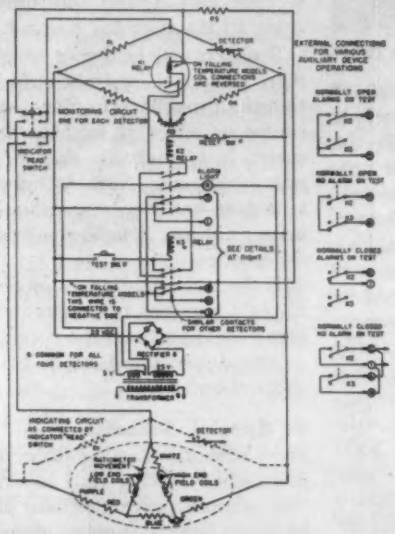
The engineer's initial assignment and his progress for perhaps two years are influenced by the knowledge and information gained in school. Thereafter, both his personal advancement and his value to his company depend on his professional growth. The man must have the initiative, the perseverence and the willingness to grow; the company can provide the incentive, the encouragement, and the environment.

Professional Environment. It is a well-established fact that sound and creative thinking is fostered by an environment which "sets the stage" for it. Many factors enter into the intangible thing called "environment," some of which, individually, appear trifling and insignificant. Put together in the proper manner, however, they build the whole structure just as surely as bricks are component parts of the house. Let's exam-

* In order to avoid excessive repetition, the terms "technical personnel" and "engineers" are used synonymously herein. Unless specifically indicated both terms will include all persons with professional technical training and neither is to be confused with a job title designation.

Questions and Answers on the EDISON OMNIGUARD SYSTEM

The Most Effective Means of Measuring and Safeguarding Temperatures and Pressures



Q. How does the Omniguard System work?

A. Edison's Omniguard is characteristically simple and unique in its operation. Each Omniguard channel is a conventional D-C Wheatstone bridge circuit in which an Edison temperature or pressure detector forms the variable leg of the bridge. As the temperature or pressure rises and falls, the detector resistance increases or decreases. An Edison relay (K1) across the bridge senses the current flowing through it. When conditions are normal the current flows in the direction to hold the relay contacts open. When a variation occurs, however, current flow reverses and the contacts of this alarm relay close. Relay K1 energizes the coil of auxiliary relay K2 which actuates an alarm light on the panel face to show which detector is "off-normal," actuates an external alarm or annunciator and maintains the alarm indefinitely – until conditions have returned to normal and the normally closed reset switch is opened.

Any temperature or pressure can be read at any time by pressing the indicator read switch for that point.

Q. Is Omniguard dependable?

A. Reliability is built in. Since each measuring channel is an independent, separate circuit, complete system failure is unlikely. Only the most reliable components are used. Edison resistance temperature detectors don't "drift" over years of service. There are *no* scanning mechanisms to wear out . . . *no* delicate components . . . *no* electronic circuits . . . *no* amplifiers . . . *no* periodic maintenance requirements.

Q. Is Omniguard flexible?

A. Completely. A system can monitor as few as 4 or as many as hundreds of variables. Buy only what you need. Since channels are independent of one another, each can be set to alarm at a different temperature or pressure. Alarm settings can be changed easily and quickly.

Omniguard can be used for alarm or shut down of equipment, alarm can be local and remote, is easy to telemeter to remote control station.

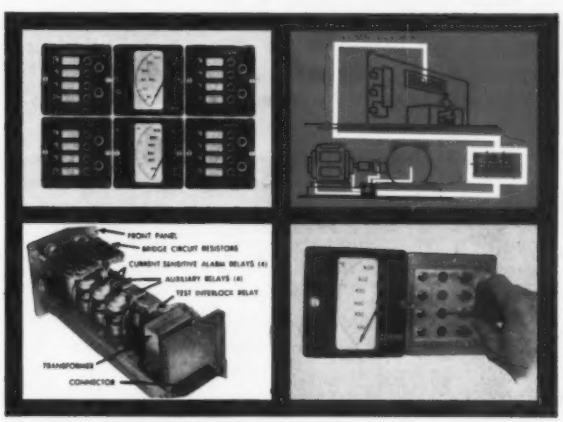
Q. Is installation economical?

A. Omniguard is the simplest system available. Fewer parts mean lower costs, less maintenance. Plug-in monitors are installed in minutes with no special tools or calibration. Ordinary copper wire connects remote detectors to monitors. Monitor units act as their own annunciators, identify each temperature and pressure, eliminating the need for extra equipment in most installations. Omniguard is a *complete* system with all parts including hardware supplied by Edison.

Q. How accurate are Edison's Resistance Temperature Detectors?

A. In the range from −200°F to +1350°F, no other type of detector is as stable, sensitive, and accurate over years of service. Response times of 0.8 seconds are common – detectors are repeatable to .05% over years of use, resistance being directly proportional to temperature.

Resistance Pressure Detectors are accurate to 1% or better depending on pressure range.



For complete information on the Edison Omniguard System, industry's simplest, most reliable means of continuously monitoring critical temperatures and pressures, write for Bulletin 3036C.

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ine some (but not all) of the many factors which go to make-up this environment.

1. Professional Advancement. One serious and ever-present danger in a company which employs many engineers is that of intellectual stagnation. When any person is kept too busy at regular or assigned work, his creative thinking ability tends to decrease. Consider, for example, the engineer whose directions and information come only from supervisors, fellow-workers and in-plant experiences, and neither takes nor is given the time to read, study, wonder, and to explore. In time intellectual inbreeding and attendant ill-effects will result.

Management which works on the theory that engineers can do their best work under the pressure of heavy assignments is short-sighted indeed. On the other hand, the engineer himself is negligent if he does not find the time to do some reading and thinking, even if it has to be "bootlegged" and he feels somewhat guilty about the apparent slowness with which he is completing his regular assignment.

The rate at which technical developments occur is such that no progressive company and no wide-awake professional man can afford to ignore them. Both must keep moving ahead through continued and diligent effort or run the risk of being left far behind. Since "the company" is the composite of all its employes, the broader the knowledge and ability of the individual engineer, the more valuable he is to the company. Hence it is imperative that companies provide opportunities for technical personnel to keep up with that which is being done. A few of the ways of doing this are:

1. Libraries
2. Seminars and lectures
3. Special schools
4. Professional society meetings
5. Publications

But let's examine these one at a time.

Library. The ready availability of good reference books and an ample supply of current literature is the very foundation of any type of professional program. The policy of providing individual subscriptions to a limited number of magazines is a step in the right direction, but certainly is no substitute for a good library and the opportunity to use it.

A library should provide readily available and attractive reading, study and search facilities. The annual outlay for books and periodicals can be quite modest (e.g. $500 per year) for companies with only a few technical employes or much larger as conditions dictate in the larger companies. If at all possible the library should be cared for by a professionally trained librarian.

Finally, the work load of the technical personnel should be such as will permit (indeed, encourage) them to use the library facilities. Its use should not be limited, by rule or custom, to research and development men only.

2. Seminars and Lectures. Frequent in-plant seminars and lectures on special topics of current interest are both helpful and stimulating. Some of these may be single-session discussions, while others may need to be extended over one or more weeks. In the latter case, all employes who attend the lectures should be relieved of other responsibilities so they can devote full time and study to the material covered.

Speakers may be drawn from company personnel, or from outside authorities brought in to give a specific course or series of lectures. In any event, it is probable that best results will come from lectures presented at levels corresponding to at least graduate courses in first-class universities.

If the technical staff is limited and in-plant seminars not warranted, the men should be given the opportunity to attend special lectures and conferences elsewhere.

3. Special Schools. Those engineers who are starting or who give promise of moving into supervisory and administrative positions should be given special training. Some can be done locally, but this should be followed by attendance at special management training schools.

4. Professional Society Meetings. Engineers should be encouraged to join appropriate professional societies and attend national meetings of these societies. Technical papers presented at such meetings are important, but "corridor bull-sessions" are also very potent areas of information exchange. One or more men should be more or less regular attendants of the national meetings of each of the major professional societies, and each engineer who is a member of a technical society should be given the opportunity to attend at least one meeting of his choice each year.

Occasionally a company has a formally adopted policy of encouragement which is not followed satisfactorily by company practice. A stated policy which is not effectively used, is worse than no policy at all.

5. Publications. Both individual and company prestige are enhanced by publication of technical papers, hence company policy should sanction and encourage presentation and publication of material by technical

TABLE 1—Salary data for June and August, 1959 B.S. graduates in chemical engineering at The University of Texas

Salary Range Per Month	PETROLEUM		CHEMICAL		OTHER	
	Offers	Acceptances	Offers	Acceptances	Offers	Acceptances
400—439	1	1	..	..	2	2
440—449	..	..	..	..	..	..
450—459	..	..	1	..	1	1
460—469	..	..	..	..	..	..
470—479	1	1	3	2	..	..
480—489	2	..	3	..	..	..
490—499	3	..	4	4	..	..
500—509	4	3	10	5	1	..
510—524	3	2	6	2	..	..
525—540	2	1	4	2	..	..
Over 540	2	2	1	..	..	..

	AVERAGE SALARY	
	Offered	Accepted
Petroleum	$509 (504)	$514 (494)
Chemical	$502 (475)	$502 (482)

Figures in parentheses are corresponding data for January, 1959 graduates.

ADVANCED DEGREES

Offers to advanced-degree men are widely varied and more nearly on an individual basis. For example, four offers to one M.S. candidate were $525, $550, $570, $620 (accepted). Average offer was about $600/month.

Doctorate candidates received offers ranging from $715 to $840 per month. Average of 20 offers to 4 men was $785 per month.

personnel. Of course, suitable clearance procedures must be followed, but these should not be so rigid or cumbersome as to stifle the initiative of those who want to write a paper for presentation at a technical meeting and/or for publication.[2]

Beware of Isolationism. No engineer can make an optimum contribution to his company unless he has a broad knowledge of company operations and unless he knows and has confidence in fellow workers and supervisors. In spite of this, however, there are still companies in which a policy of isolationism and "hyper-confidentialism" prevails on both horizontal and vertical planes.

The wide-spread reluctance to distribute information appears to stem from a fear that someone else will learn something which, for some mysterious reason, should be withheld. As a result, the information (?) is spread by rumor—and grows as it spreads.

These cancerous conditions can and should be combatted in several ways, some of which are:

1. Circulation. Information concerning company operations and future plans should be circulated to the maximum extent. It is far better for the men to be over-informed than under-informed, and an objective examination will reveal that there are far fewer confidential company "secrets" than most people suspect.

2. Contact. More personalized contact between managers, supervisors, and engineers both on and off the job is desirable. Most men will turn in a far better performance for the man whom they know at church, at the civic club, on the fishing trip, or at the frequent company picnic as "Jim" than they will for "Mr. Jones." More than likely, Mr. Jones is known to them only by his name on a letter or on his closed office door.

3. Assignments. A plant-wide custom of frequent interchange of assignments, vertical and horizontal breaks down isolationism. It also affords one of the best ways of maintaining a reserve of capable, broad-thinking men to fill temporary or permanent vacancies as they occur. No engineer should remain on one job longer than three years in succession. This cannot be overstressed.

About the Author

William A. Cunningham is a professor of chemical engineering at The University of Texas where he has taught since 1935. After completing his first two degrees there in 1929, he joined Texas Industry, later became associated with the management of the University's mineral-rich lands, and from there was assigned to its Bureau of Industrial Chemistry where he received a research appointment and an opportunity to study for his Ph.D. degree. He began instructing chemical engineering classes while still a degree candidate and now is a member of the graduate faculty. He is a past national director of AIChE.

Professional Recognition. There are few men who do not desire recognition for that which they do. One who conscientiously seeks professional advancement is always willing to listen to criticisms and suggestions whereby his work can be improved. He also appreciates commendation for a job well done.

Within a company organization recognition can come from several sources, but they can be grouped under the two simple headings:

- Personal.
- Financial.

The second is more definite, but if this financial recognition is adequate, it is of lesser basic importance than personal recognition. However, both must be adequate if the engineer and his company (the possessive "his" is used deliberately) are to have common objectives. Let's view each a little more closely.

Financial Recognition. It is commonly recognized that no man can long engage in constructive thinking unless he has no worry about meeting his basic financial needs, and he is reasonably satisfied that his pay is consistent with that which he might get elsewhere.

The engineer should be able to advance along either of two routes, namely, supervisory or technical. If optimum utilization of engineering manpower is to be realized, it is imperative that sound and workable parallel programs be developed and put into effect. It is wasteful indeed if a capable technical man must be forced into the supervisory route in order to get financial recognition commensurate with his technical ability.

Keep in mind, however, that advancement should be on the basis of individual merit and not retarded by a lethargic system of review. Neither should it be tied to an inflexible allocation of a fixed number of salaried position levels in any given area.

An engineer who graduates from any recognized school—i.e. one whose curricula are accredited by the Engineers' Council for Professional Development—has already made an investment of at least $5,000, exclusive of deferred earning. Most of them take pride in the fact that they are new initiates in the engineering profession; they expect and are entitled to adequate compensation.

Establishment of equitable salary scales for technical personnel is not simple, but financial recognition of a man's ability and merit is an absolute requisite to optimum utilization of that ability. In passing it should be noted that the rather prevalent custom of giving scale increases to all technical personnel only as an appendage to similar increases to non-technical personnel which result from labor union negotiations is not conducive to the maintenance of a high professional attitude.

Personal Recognition. Personal recognition of the type which enhances prestige but not pride is essential to maintenance of morale. High morale leads to high productivity.

Certainly high standards of professional environment as presented previously are paramount. The productive engineer must enjoy or "have fun" at his work and his accomplishments; he must take pride in what *his* company does; he must feel the importance of his job and that he is able to contribute to the successful operation and management of his company. In turn, the company (which means the man's supervisors) must give him appropriate personal recognition. Some of the things which enter into this are:

1. Working Conditions. Proper working conditions and equipment are of vital importance. "Bull-pen" conditions of five or six men crowded into a single room are to be avoided. As a rule, two men in a well-lighted and appointed room have proved most satisfactory and productive. It goes without saying that ample supplies should be readily available. Penurious penny-pinching policies in this respect are annoying far beyond monetary value of any savings incurred.

2. Job Titles. Prestige-wise, job titles are more important at home and away from the plant than they are on the job—but the often-referred-to "power of a woman" is not to be disregarded. For example, the title "Foreman" has been associated for so many years with the lead position in a group of nontechnical workers that its use otherwise tends to be misleading. Some other titles, e.g., "Section Head," would be far more acceptable at home than would "Technical Foreman."

3. Tell a Man He Has Done a Good Job. Although no one should object to an objective criticism, the philosophy that a man learns only by being "chewed out" when he does something wrong is poor indeed. Any man likes and deserves to be commended for doing a good job, and this positive approach is usually quite effective in developing constructive thinking and initiative. The negative approach tends to make a man more cautious and less willing to take constructive action.

A system of regular conferences between the engineer and his immediate superior held at no more than six-month intervals is very productive. At these the man's progress is reviewed and he is praised or criticized as needed. Take care, however, that these are teaching sessions and not "star-chamber chewings." The men should know the basis on which they are being judged and rated, and wherein they would or should improve.

4. After-Thoughts. If your company provides reserved parking places for managerial personnel above certain levels, does it also give similar privileges to its technical personnel at corresponding levels? What about private offices? Do your engineers sign the letters and reports they write, or is the supervisor's name only on them?

Nourish the Spirit. Just as there is no royal road to learning, so is there no royal road to efficient use of technical manpower. The points we have discussed could well be expanded; each item could be considered in detail. However, a listing of the various items, no matter how complete, plus a mechanical adherence to all items and suggestions would still be inadequate if one other factor was not present. That item is most intangible—it is the spirit of personal and professional recognition and behavior.

This spirit cannot be created—it must grow. And only when it flourishes, can high morale and loyalty be maintained, the prestige of the engineer be raised, and full productivity of all abilities be achieved.

Nourishment for the spirit must come from all levels of management, indeed, from the board of directors on down.

LITERATURE CITED

[1] *Chemical Engineering Progress*, 51, No. 11, 50-52 (1955).
[2] *Chemical Week*, June 21, 1958. pp. 84-86.

Group Dynamics in Decision Making *Continued from Page 255*

The rapid turnover in the management of many organizations ("we've had six production managers in 18 months") tells the story. Replacement by itself is no solution if other conditions which arouse cooperation are absent, as they usually are in companies that try to control by a tough replacement system.

Integrative Goals. There is another system for establishing and maintaining cooperation. It is one in which the personal goals of members and the goals of the organization are fitted together so that a man is not working "for" the refinery—the two are one and the same. They belong to one another. Such a system doesn't eliminate conflict; it provides for the clash of ideas in order to influence decisions, rather than having these ideas suppressed or disregarded, thereby allowing them to fester and erupt into chronic organizational illness, as too frequently happens in authority-obedience systems.

An integrated goals system can lead toward increased openness or "leveling" between steps in an organization and, therefore, contribute to improved communication. By aiding individual members of the organization to diagnose the needs of other individuals and of groups, it can help achieve organizational goals without using authority-obedience as the basis of control.

Placed in the perspective of managerial thinking based on authority-obedience, applied group dynamics as learned in management development laboratory will help managers invent or perfect systems of human cooperation to replace an authority-obedience system which is not working well and which produces many undesirable side effects, even when it is working smoothly. Such changes can increase motivation and lead to a sounder operation through better decisions with individual, group, and organizational goals.

A 5 or even a 10 percent increase in effective decision-making can do a lot for refinery's P/L statement. It can be done. Indeed, it must occur if refineries, or other organizations for that matter, are to keep pace with the explosion now occurring in scientific, technological and human knowledge. Antiquated 19th century ways of doing things must be replaced with 20th century understanding if capitalism as we know it is going to work.

At a general level, a management development laboratory explores the consequences of the two broad theories of management—one based on authority-obedience concepts of power, the other on the integration of personal and organizational goals as the basis of collaboration. The exploration takes place in a manner which is far different than ordinary training programs—as will be shown in Part 2 next month.

Part II, which will appear next month, will discuss such highly interesting and informative points as:

1. **The strategy for acquiring knowledge.**
2. **How feedback reflects human behavior.**
3. **How to organize a management development laboratory.**
4. **How to assess the behavior of others.**

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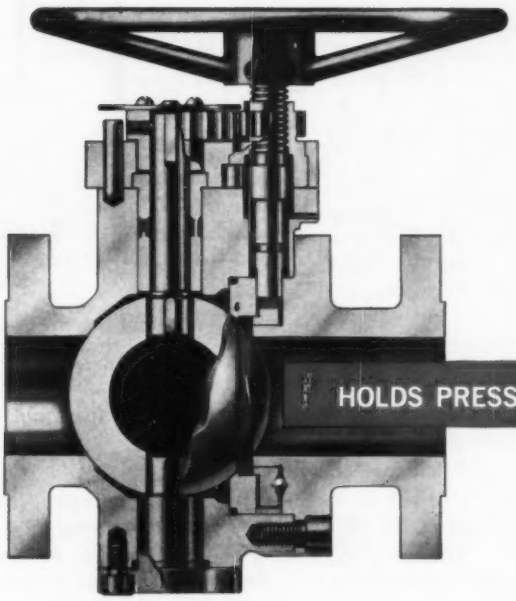

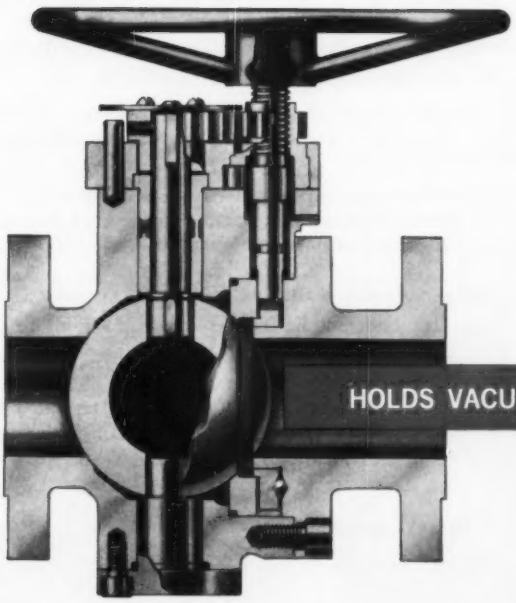

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Design of Hydril Type "K" Ball Plug Valves assures minimum maintenance costs. Non-lubricated, they employ no sealing lubricants. There's no sliding friction between plug and body to produce wear and abrasion.

The spherical plug is mounted on accurately positioned bearings, maintaining a minimal controlled clearance between plug and body. This contributes to easy, free-turning operation as well as to long service life.

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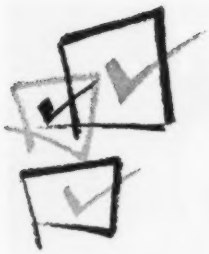

Test Yourself on Labor Relations

No. 1 Fire a Man for Loafing?

The company and the union were in the midst of negotiations. The meetings were private and held on company premises. The situation in the plant was quite tense and rumors flew thick and fast. On one of those days, the plant manager decided to tour the plant. His particular target was the maintenance department where control records showed that things were not quite up to snuff.

In order to better observe what was going on, he decided not to make his presence known. Instead, he hid behind a pole and took out a notebook to record his observations. He did this for four hours. At the end of that time, his notebook showed that Bill Wells had not done a stitch of work. It seems that Bill spent all that time talking to other workers, visiting the washroom, leaning against vending machines. Bill's foreman was seen wandering around without taking any action about the loafing. The plant manager called all the workers of the unit together and told them what he had observed and noted down. He then called Bill into his office and read to him the notes he had taken during that time.

"I guess I haven't done any work," Bill admitted. "We're all nervous about those negotiations."

As a result, Bill was let out for "loafing on the job."

At arbitration, the company stood by Bill's own admission. Bill brought up his work record which was fair, except for a warning slip a year earlier for "clocking out early," and he demanded his job back.

Test Yourself:

Was Bill RIGHT ☐ WRONG ☐

No. 2 Rights of Union President

"The roving Ambassador" was what management called union-president Jilling. He was always wandering around the plant talking to employes. He claimed this was part of his job—to discuss problems with union members. Further, he said this helped management because his talks helped straighten things out. When negotiations came up the company insisted on a clause limiting Jilling's movements. The following clause was accepted:

"The local president shall request permission to take reasonable time off for investigation and adjustment of grievances without loss of earnings. Such permission shall not arbitrarily be withheld."

One day Jilling came up to his foreman and asked for permission to leave his job.

"What for?" his foreman asked.

"I've got to look into the workman's compensation claim of Bill Howell in the next department."

"Doesn't sound like a grievance to me. I'll check." And the foreman picked up the phone and called Howell's foreman. "There's no grievance there. You can handle it on your lunch hour," was the foreman's decision.

Jilling left his job and went to check into the matter. He was disciplined. At the arbitration he said:

1. My job is to investigate and adjust grievances. How do I know there's no grievance unless I go and look.
2. Grievance investigations should be made right away. Serious things may result from delay. This is for the company's benefit as well.

The company wasn't swayed by this approach:

1. Our contract limits the union president to grievance investigations. A workman's compensation problem is not a grievance.
2. If our foremen make a mistake and arbitrarily withhold permission, then the union president can use the grievance machinery. He can't just go off on his own.

Test Yourself:

Was the company RIGHT ☐ WRONG ☐

Answers on Page 374

ENGINEERING NEWS

NATIONAL AIROIL BURNER CO., INC. • 1284 E. Sedgley Ave. • Philadelphia 34, Pa.

You may wish to check certain items in this advertisement and forward to those concerned in your company.

ROUTE TO:

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National Airoil Offers Broad Line of Oil and Steam Hand Firing Valves

We are often asked to suggest the correct valves for regulating oil and steam supply to burners in petroleum and chemical industry applications. Initially, consideration should be given to the grade of oil, its composition, viscosity, temperature and pressure at the burner. For atomizing steam supply, it is important also to know the pressure, quality or total temperature.

National Airoil Bronze Valves are suitable for medium pressures and temperatures. The National Airoil 232 "V" port all-bronze plug valve is recommended for oil temperatures up to 225°F and 75 pounds pressure. This valve is also ideally suited for acid sludge. The National Airoil 231 all-bronze globe valve is recommended for atomizing steam pressures of up to 150 pounds gage or a total temperature not in excess of 375°F. Although bronze valves are the lowest in cost, they are not commonly acceptable to oil refineries where steel is the standard material for all steam and oil piping.

National Airoil Steel Valves Where high temperature oil as asphalt or vacuum tower bottoms is burned at up to 600°F or pressures up to 400 pounds, we recommend our 9847 steel valve with stainless trim. This valve is a globe type, "V" port, close regulating, it is non wire-drawing. The oil supply should be reasonably clean or free from larger particles of coke that might build up in the port.

In those instances where high temperature oil, containing particles of coke is fired, the National Airoil all steel, "V" port, 9195 plug valve can be used. Although it is not entirely free from port clogging by coke, it can be easily cleared by momentarily opening it wider to flush through any coke build up. This valve is generally not considered as a positive shut off, it should therefore, be provided, up stream and in series, with a suitable shut off valve. This practice should also apply to all oil and steam control valves.

When superheated steam of up to 600°F total temperature and pressures up to 200 psig is the atomizing medium, the better valve is the National Airoil 9077 with steel body and stainless stem.

All valves described above are fitted with pointed handles and a graduated indicating device.

Bulletin 90 contains complete details on the broad line of National Airoil Valves. May we send you a copy?

Do You Have These National Airoil Technical Bulletins In Your Library?

Whatever your industrial heating problem, you'll find a wealth of helpful information in these technical bulletins. Write for any or all of them today.

BULLETIN No. 40. FUEL OIL PUMPING AND HEATING UNITS

16 pgs. Here's the answer to problems involving preparation of heavy fuel oil for combustion. Single and duplex units, from 2 to 100 gpm in standard or special models.

BULLETIN No. 28. AUTOMATIC PACKAGED FIRING UNITS

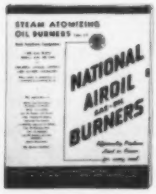
4 pgs. Steam atomizing automatic firing units for oil and/or gas fuels. Standard unit capacities—from 200 to 830 boiler horsepower (7,200 to 30,000 lbs. of steam per hour). Larger units for special needs.

BULLETIN No. 25. DUAL STAGE OIL BURNERS

4 pgs. Data points out advantages when *both* mechanical and steam atomizing principles are incorporated in a single oil burner. 3 standard sizes are shown.

BULLETIN No. 51A. UNIVERSAL REGISTER UNITS

4 pgs. Data offered on full line of these quality National Airoil products with capacities ranging from 60 to 500 gph.



BULLETIN No. 21. STEAM ATOMIZING OIL BURNERS

16 pgs. Describes "SA" Burner for use where steam or compressed air is available for firing many types of industrial process furnaces. 5 sizes have rated capacities from 10 gph to 725 gph.

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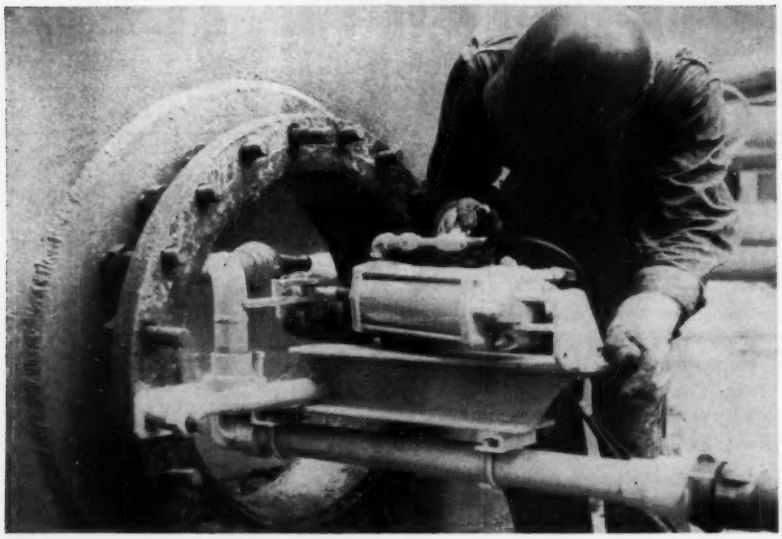
How to Do It...



Tank Washer Cuts Those Cleaning Costs

Brine storage tanks at Dow Chemical Co.'s Freeport, Texas plant periodically required a considerable amount of hand cleaning. To speed up the cleaning operation and cut labor time, a plant pipefitter, J. W. Weber, developed an automatic tank washer shown in the photograph.

Design. The washer consists basically of a set of twin nozzles which sweep the tank interior on arcs up to 180 degrees, a hydraulic cylinder to rotate the nozzles, and a solenoid valve to change the sweep direction. The washer is attached to a tank manhole by means of a bracket that slips over two manhole-cover studs. It can be placed in any of the stud positions for the sweep desired.

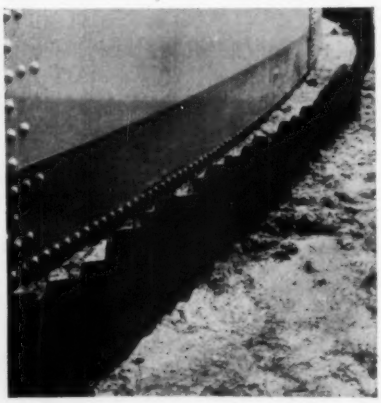
Operation. The operator can be seen adjusting the hydraulic cylinder, water-inlet valve which in turn controls the speed of the cylinder piston. A bracket is welded to the main water-supply pipe through which an eye bolt from the hydraulic-cylinder piston plunger is attached. A solenoid valve diverts cylinder water from one side of the cylinder piston to the other causing a continuous movement of the nozzle heads.

A standard coupling can be seen (lower right of the photo) to which is connected a hose supplying cleaning water.

This item was previously published in *The Dow Texan,* a publication of The Dow Chemical Co., Texas Division.

Build Dam Around Storage Tank and Locate Leaks

At Texaco Inc.'s Port Arthur refinery, an effective method is being used to locate and repair leaks in tank farm storage tanks.

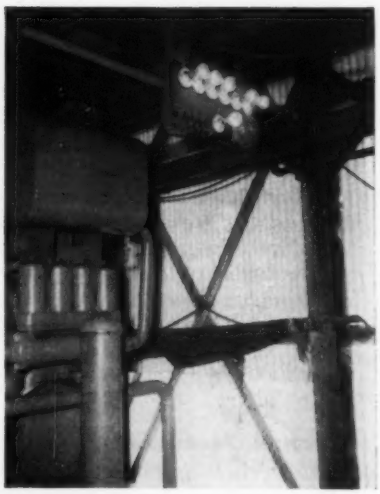


Short 2-foot lengths of 7-gage interlocking sheet piling are driven about 8 inches deep around the perimeter 18 to 24 inches away from the tank wall. The space between the sheet pile and tank is then filled with water that flows underneath the tank bottom. This creates a small head that forces the water up through any holes in the bottom, making it possible to locate the leaks. Because there is such a low head, the bottom is hammered to break off scale that might prevent water from entering the tank.

As water enters the tank, each leak is contained by a mud ring or dam, usually 6 to 12 inches in diameter. This prevents the water from covering the entire bottom area and concealing the source of the leak. When the water is released from the tank, boiler makers come in and repair the leaking areas by patch welding.

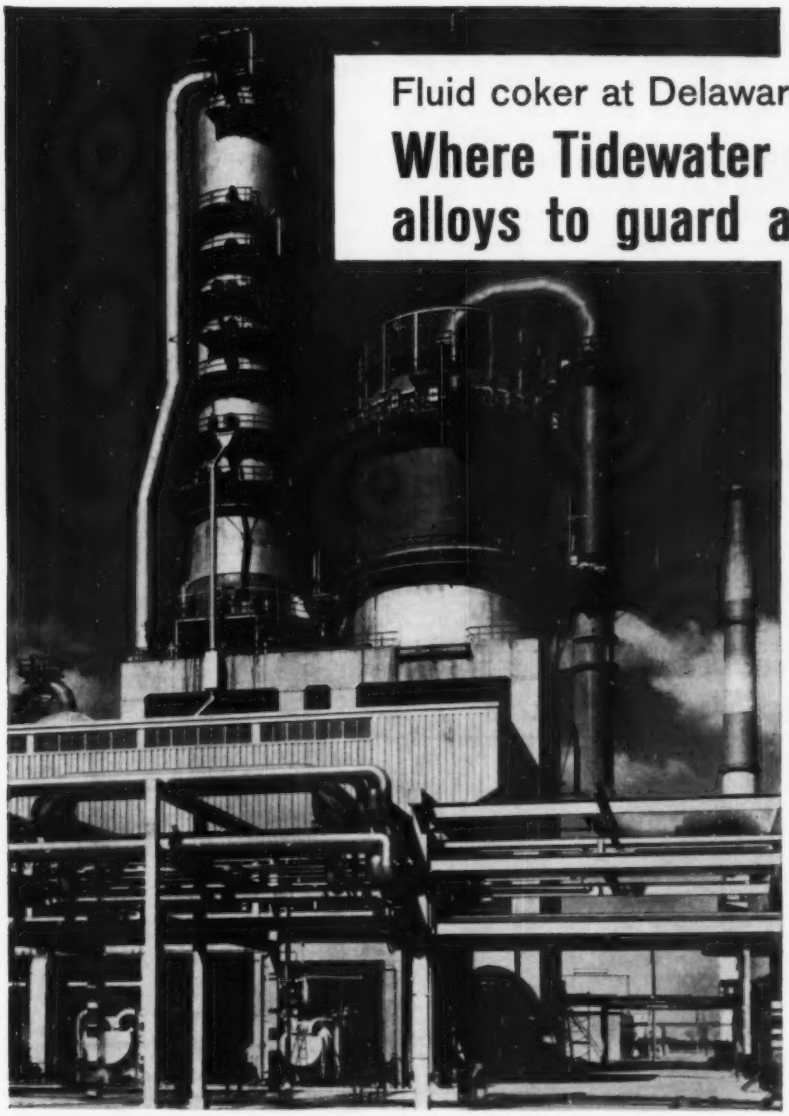
Later, when grout foundation material is pumped under the tank, the interlocking sheeting retaining wall helps to stabilize it.

This idea was submitted by Armco Drainage & Metal Products, Inc.



Lights Warn Operator When Something Is Wrong

A warning system connected to a plant's 110-volt lighting system was devised by one refinery foreman to warn the operator when something is wrong on any pumping unit. The circuits were run so that the lights in the upper row remain on when the water-jacket temperature, oil pressure, fuel supply, etc., of any of the units is running within operating limits. Whenever the limits are exceeded in any of the units, the appropriate light in the upper row goes off and the red light in the lower row



Fluid coker at Delaware Refinery...

Where Tidewater uses high nickel alloys to guard against corrosion

Here's the fluid coker at the Tidewater Oil Company's huge Delaware Refinery, which was specifically designed to operate on sulphur-bearing crudes or those containing considerable naphthenic acid.

Like other units in this refinery, the fluid coker reflects modern practice in economical corrosion protection. To provide this protection, Tidewater engineers took full advantage of the properties of high nickel alloys. You'll find the details in the table below.

Throughout the refinery, high nickel alloys such as Monel* nickel-copper alloy and Inconel* nickel-chromium alloy combat corrosion by mineral acids and other troublesome corrosives.

For more information, or for help with a corrosion engineering problem that's giving you trouble, write us. *Inco trademark

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

Schedule of Use of Monel nickel-copper alloy to combat corrosion by aqueous H_2S and HCl in fluid coker at the new Tidewater Refinery**

	EQUIPMENT	LOCATION	MATERIAL
Columns:	Fractionator	Top head	Monel-clad steel
		Shell, tray #17 to top	Monel-clad steel
		Trays #17, 18, 19	Monel alloy
Vessels:	Fractionator-accumulator	Nozzles	Monel alloy
	First commingler drum	"	" "
	Second commingler drum	"	" "
	Stabilizer accumulator	"	" "
	Blowdown quench drum	"	Monel alloy
	Main water seal vessel	"	" "
	Bypass water seal vessel	"	" "
Pumps:	Foul water pump	Casing, Impeller	Monel alloy
Piping:	Foul water line, accumulator to stripper		Monel alloy

*Inco trademark

**Where temperatures go above 500°-550°F, nickel-containing type 316 stainless and stainless-clad steel are also extensively used in this unit.

MONEL.®

For more data on advertised products, use Readers' Service Cards, last page.

is lighted. An alarm bell is also in the circuit so that it will sound and warn the operator to look up at the panel. He can make the necessary adjustments or repair or shut down the unit before any damage is done. Each of the warning switches has a bypass unit for test purposes. When the accompanying photo was made, the number four unit's water-jacket temperature was short circuited causing this light to go off, the lower light to come on and the alarm to sound.

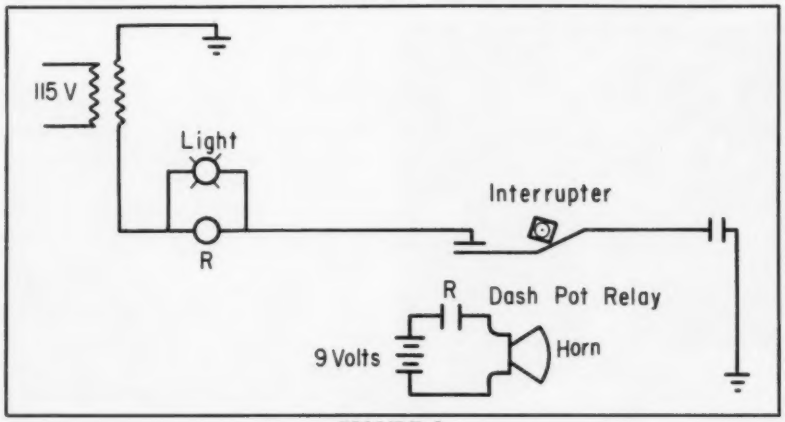


FIGURE 2

Indicator Checks Pump Speed, Failure

In many instances it is desirable to have both an audible and visual indicating device to check on pump operating cycles. Such circuits once employed the conventional dash-pot and parallel-lamp techniques—but with the development of thermal relays, plus the standard plug-in relays, an improved performance can be achieved. Figure 1 shows the use of such components, along with two lights installed in a metal cabinet. The use of these sealed, plug-in relays are easy adaptable to circuits employing the low-current circuits common to long-distance signal service. Maintenance costs are low because the apparatus is both durable and easily capable of replacement by non-skilled workmen. The sealed-in type is impervious to dust and moisture.

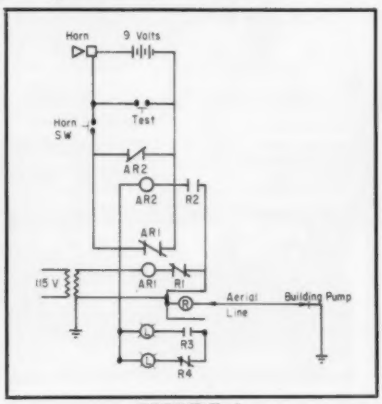


FIGURE 1

Figure 2 indicates a second type of indicating device with a field wire extending from the remote pump to a manned station. In this circuit a small gear reducer is coupled to the pump shaft which actuates a set of contacts. Assuming this reducer has a ratio of 10 to 1, with the pump turning at 600 rpm, the contacts operate approximately 60 cycles per minute. The vane switch and the contacts are wired in series and connected by a vane switch aerial line to a dash-pot type relay. Connected across the coil of the relay is the station's indicating light, and in series with the relay is an electric horn.

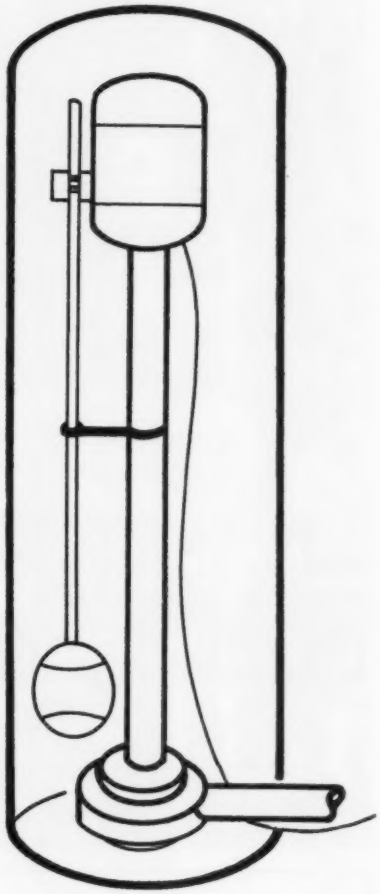
When the pump is running, the vane switch makes contact 60 times per minute to send flashes through the indicating light and relay at the manned station. By special arrangement, the armature of the relay is sufficiently damped so that before it may complete its available drop, the relay is re-energized to raise the armature again. This action is too fast to close the horn circuit contacts.

The flashing light shows the pump's speed and the vane switch provides failure indication should the pump stop or stall with interrupter contacts "made."

This idea was submitted by Warren Cross, Oak Ridge, Tenn.

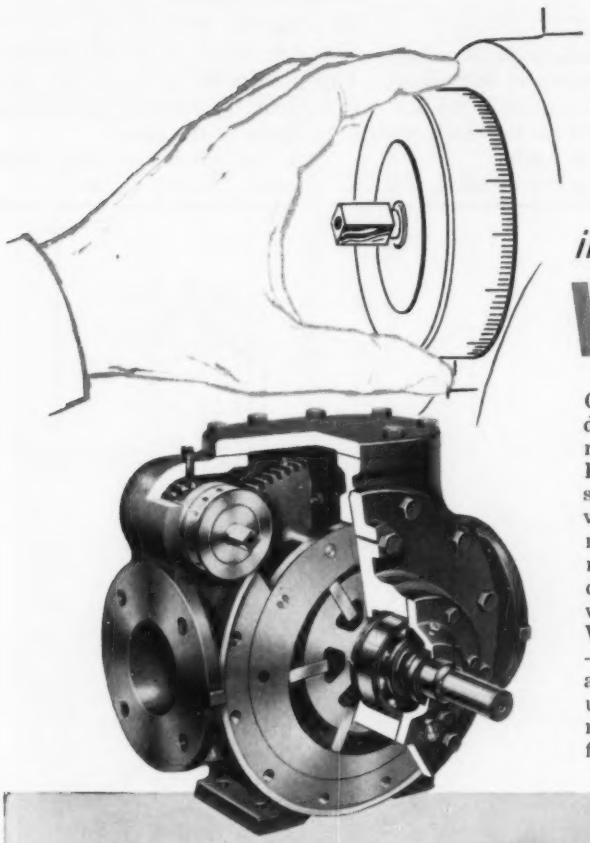
Diving Bell Added to Sump Saves Drownouts

One plant uses bunker fuel stored in heated and lagged underground tanks. It is circulated to the burners in a closed circuit maintained by a centrifugal-type pump located on the boiler room level.



The tank pit and service tunnel has been drained of seepage water by means of a quarter-horsepower, vertical-type sump pump having a motor mounted about three feet above the single-stage centrifugal base. On two occasions, the pump failed to keep the area drained and was shorted-out by high water. Once a water main broke, and another time, a flash flood silted up a ditch. The resulting dam diverted water to the soil-filled area above the tunnel and fuel-tank pit.

When the fire department pumped the water out the second time, and the pump motor was baked dry once again, the company developed the idea of a diving bell to drop over the motor and pump assembly. The bell consisted of a 3½-foot long section



NOW! DIAL ANY FLOW

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VARI-FLO PUMPS

One Speed — Any Flow Rate! Just a turn of the dial, and the Vari-Flo delivers exactly what you need . . . as you need it. Essentially, the Vari-Flo is a highly efficient vane-type pump with a simple means for changing its displacement to vary delivery from zero to full capacity while running at constant speed. Without changing rotation, it can even reverse its flow to evacuate discharge lines after shutoff! The need for costly variable-speed drives is completely eliminated. With Vari-Flo, you change pump displacement — never the speed. Truly the most versatile of all pumps, the new Blackmer Vari-Flo offers unique solutions to countless pumping problems requiring quick or accurate control of liquid flow.

VARI-FLO makes proportion easy and economical

The development of the Vari-Flo pump provides a new approach to simplified liquid proportioning. Typical applications for Blackmer proportioners cover a wide range of liquids and processes including the blending of fuel oils, asphalt, gasoline, lube oils, solvents, waxes, chemicals and many others. The low first cost of such an installation, coupled with its ease of installation and maintenance, can effect remarkable savings over the complex equipment that was once required.

FREE CATALOG and ENGINEERING ANALYSIS

For complete information, write for Bulletin 600

"liquid materials handling" ® equipment

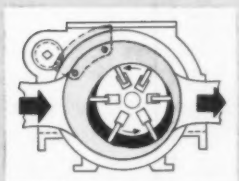
BLACKMER

VARI-FLO PUMPS

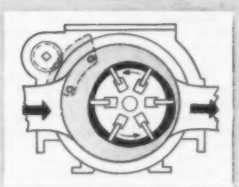
BLACKMER PUMP COMPANY

1809 Century, S.W., Grand Rapids 9, Michigan

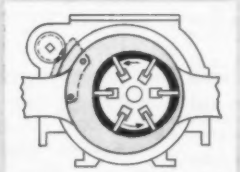
Flow control is simple and positive:



100% FORWARD FLOW. Maximum flow from full-size pumping chamber at bottom. Rotor and movable liner (shaded area) are tangent at top.



PARTIAL FORWARD FLOW. Dial rotates liner to decrease width of pumping chamber, reducing forward flow. Portion of flow is carried back at top.



NO FLOW. Liner is rotated to neutral position, equalizing areas above and below rotor. Liquid recirculates inside the pump.

REVERSE FLOW. Liner is further rotated, resulting in more liquid being carried back across the top than forward across the bottom. Flow is reversed without changing pump rotation.

For more data on advertised products, use Readers' Service Cards, last page.

. . . one of a series presented by Western Supply Company, Tulsa, to improve the "I.Q."* of engineers . . . (*"Income Quotient")

Personal, professional advancement demands thorough engineering knowledge, disciplined habits, creative thinking, constant application

"Intellectual let-down" — that tendency so common to many engineers to "stop learning" as soon as they acquire a sheepskin — will be completely out of style by 1999. Indeed, it is passe in today's accelerated engineering profession, because to stop learning is to stop growing: to stifle imagination, to throttle creativity, and ultimately to kill scientific progress.

The engineer who would keep pace with his own industry — especially the process industry — must determine to follow a prescribed, disciplined course of action, if he is to achieve the stature, prestige, responsibility and income to which he aspires. He must recognize that only as his engineering achievement advances will his personal well-being also increase.

There is no magic formula for the "successful engineer," but for what they are worth to your professional future, here are 14 "ground rules" for your consideration:

Set objectives for your professional and personal life, re-examine them periodically, but always work towards a goal in life.

Develop sound work habits. Earn a reputation for promptness, attention to detail, accuracy, diligence, reliability.

Continue to study your chosen field or specialty. Your learning process must never cease functioning.

Seek additional training, technically or in non-technical fields which can be of importance to future development.

Think creatively about your job, your company, technological advances and developments. Dare to think **beyond** your capacity.

Expand your capacity to discover new fields of endeavor, discriminatingly, however, so that they will have application to your objectives.

Take a genuine interest in people, their potentials, their problems. Understand, but don't condemn, their shortcomings.

Broaden your base of appreciation for other pursuits, such as sales, accounting, law, advertising. They, too, are important to your company.

Study the fundamentals of business. Learn the economics of your company, its basic philosophy, its obligations and responsibilities, its opportunities and limitations.

Seek advice and counsel from others; don't rely entirely on your own resources . . . Ask questions.

Participate actively in technical societies; keep alert to professional trends, changing concepts, new developments.

Use common sense and sound, practical judgment in evaluating everything from people to processes.

Aggressively pursue your professional and personal ambitions, but with patience and intelligence.

Learn to communicate your ideas and opinions pleasantly, clearly, concisely, aggressively to your superiors, associates, subordinates.

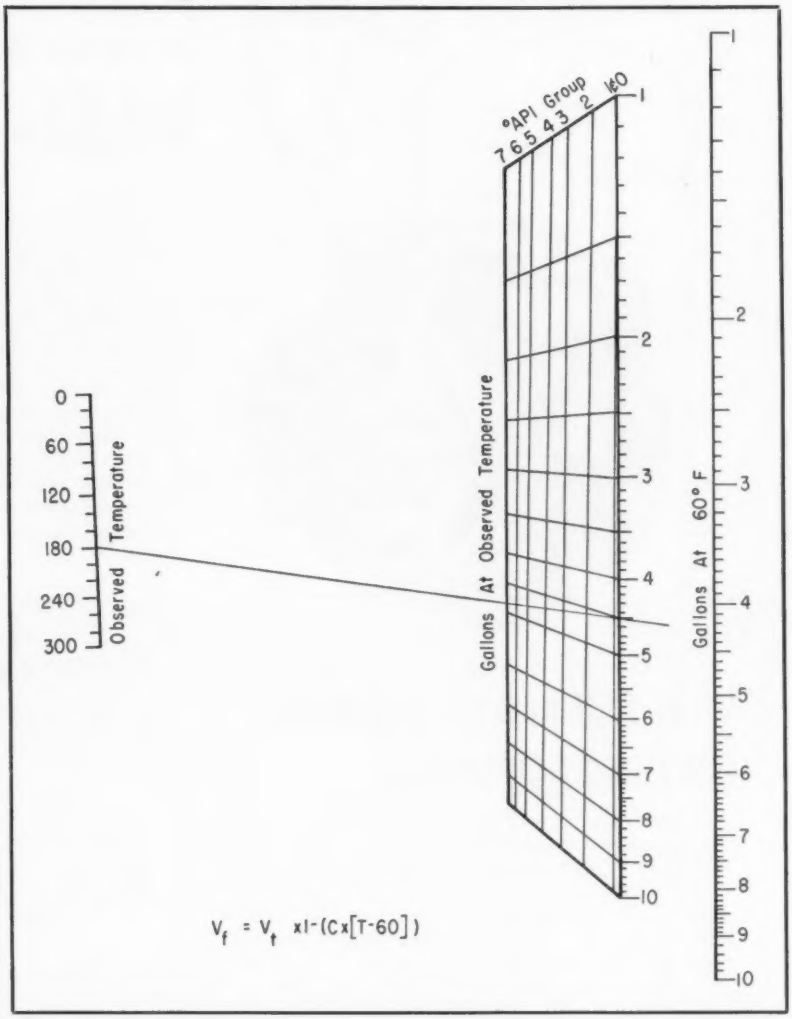
The development of a successful career in engineering bespeaks **constant, consistent dedication** to professional and personal principles. Perhaps these few paragraphs can serve as a guide for your own engineering future and advancement. (Footnote: for more detailed discussion of the suggestions made herein, write for your free copy of "14 Ground Rules," to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and if there's a heat exchanger in your company's future, we'd like to demonstrate how these "14 ground rules" affect our heat exchangers!

How To Do It . . .

of 12-inch pipe with a plate welded on one end. A two-inch, half-round hole was cut with a torch in the bottom edge to pass both the discharge pipe and the power cord.

With the diving bell installed, the motor never drowns out, because the air compresses with the rise in water level and effectively seals out moisture. This permits the pump to run until it eventually catches up with the water input to the tunnel.

This idea was submitted by Paul C. Ziemke, Clinton, Tenn.



Group No.	Range of Group, API Gravity 60° F	Coefficient of Expansion per °F at 60° F	Corresponding API Gravity 60° F
0	0 to 14.9	0.00035	6.0
1	15.0 to 34.9	0.00040	22.0
2	35.0 to 50.9	0.00050	44.0
3	51.0 to 63.9	0.00060	58.0
4	64.0 to 78.9	0.00070	72.0
5	79.0 to 88.9	0.00080	86.0
6	89.0 to 93.9	0.00085	91.0
7	94.0 to 100.0	0.00090	97.0

Correct API Oil Volume to Standard 60° F

Simplification of plant calculations enables operating personnel to check liquid transfers, pumpings and tank volumes with a minimum of error. This nomograph, which is applicable to all API groups 0 through 7 (see table), permits a rapid estimation of volumes by reduction of these volumes at various pumping or observed temperatures to volumes at the common base of 60° F.

Volume correction, utilizing this

For more data on advertised products, use Readers' Service Cards, last page.

HYDROFINING REPLACES ACID TREATMENT

To eliminate pollution of air and effluent water, reduce operating costs, and to produce a sulphur free finished product, a large Gulf Coast refiner recently placed in operation the above pictured 6000 barrel per day HYDROFINING Unit designed to supplant acid treatment in processing close boiling range naphthas.

Feed stock is vaporized and mixed with hydrogen which catalytically reacts with sulphur contained in the feed stock mostly in the form of mercaptans, to form hydrogen sulphide which is further processed to recover elemental sulphur. After HYDROFINING the liquid product is washed with caustic and filtered through charcoal.

HUDSON furnished mechanical design, materials and equipment; and constructed the HYDROFINING Unit and the Fractionating Unit shown at the left of the picture.

The services of the HUDSON organization, with over 25 years experience in process design, mechanical design and construction are available to process industries in any part of the free world.

DESIGNERS AND CONSTRUCTORS OF PROCESS PLANTS FOR THE OIL, GAS, CHEMICAL, AND MINERAL INDUSTRIES

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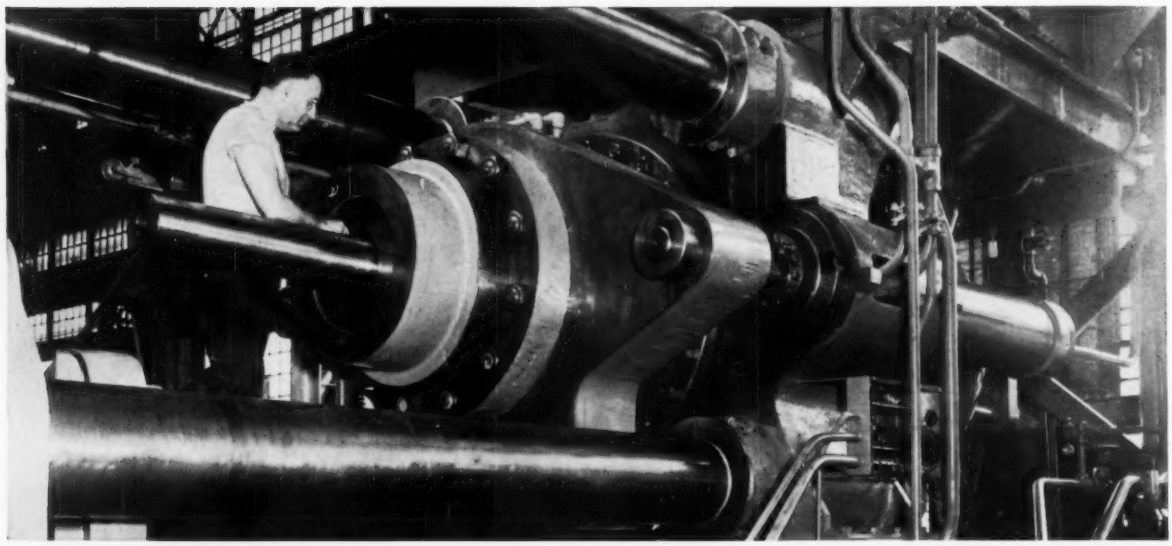

SUN SHIP has what it takes to build . . . . .

for INDUSTRY We're old hands at building complete machines and special equipment for use in a wide range of industries. For 44 years our large and amply equipped shops have produced items ranging from small tanks to huge fractionating towers, pressure vessels, stills, plate work and special-purpose machinery for the chemical, petroleum and other industries.

Pictured here are a hydraulic press, which was shipped by rail, and a fractionating tower ready for loading on a barge for shipment by water to an oil refinery. They are just two examples of the equipment Sun Ship contributes to many fields, also examples of our shipping facilities.

Because we have all the facilities, we build all equipment right in our own plant, without subletting. Our convenient location on the Delaware River, with direct access by rail and water to all points, assures speedy delivery.

Let Sun Ship solve your machine or equipment problem. Phone or write our Sales Engineering Department.

Sun

SHIPBUILDING & DRY DOCK COMPANY

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For more data on advertised products, use Readers' Service Cards, last page.

"GREAT CARE MUST BE TAKEN IN SELECTING A GASOLINE ADDITIVE"

FMC offers Dependability, Manufacturing skill, Choice of products for Gasoline Additives

Dependability – FMC protects the refiner by producing ignition control additives from basic raw materials...assuring you of optimum quality control throughout the production process, and providing you with a dependable source of supply for these products.

Manufacturing skill–FMC has a reputation for technical know-how based on more than 25 years of experience in the production of organic phosphorus compounds.

Choice of products – FMC offers you several phosphorus compounds for consideration as combustion deposit modifiers . . . will soon be in a position to supply new compounds, enabling you to choose the additive best suited to your particular conditions.

If you need a phosphorus additive to eliminate engine knock, reduce surface ignition and spark plug fouling, you can rely on the experience and facilities of FMC. Write for more information about FMC gasoline additives. We will be glad to show how these products can meet your most exacting specifications.

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION

Chemicals & Plastics Division

Sales Dept., 161 East 42nd Street, New York 17, N.Y.

How To Do It . . .

Nomograph, applies to all oils according to their API group as typified by the equation:

$$V_t = V_t \times 1 - (C \times [T - 60])$$

Where:

V_t = Volume at the base temperature 60° F

V_t = Volume at the observed temperature

T = Observed temperature, °F

C = Coefficient of Expansion per °F at 60° F for API Groups 0-7

To use this nomograph to correct the volume of oil to 60° F, connect the observe dtemperature on the left scale to the volume at that temperature on the middle scale for the appropriate API group with a straight edge. Read the volume corrected to 60° F on the right scale. For example, the volume of 4,500 gallons of API Group 0 oil at 180° F corrected to 60° F is 4,300 gallons.

This item was submitted by C. H. Blouch, Bryton Chemical Co.

Simple Conversion of °F To °C and Vice Versa

Here is a clever, simple rule for conversion of temperatures. It is faster than looking up tables. If slide rule accuracy is OK, you simply make one setting. With a computer you lock in a multiplier.

Mental arithmetic can be used for the computation. This is often handy when you are caught without a slide rule and paper.

Here's the Rule. (A) Always add 40 first—no matter which way you go.

(B) Then (1) for changing °C to °F multiply by 9/5. (2) for changing °F to °C multiply by 5/9.

Just remember that degrees Fahrenheit are bigger.

(C) **Last, Always** subtract 40.

Examples:

(D) 1. 100° C into °F
2. Add 40 = 140
3. Multiply by 9/5 = 252
4. Subtract 40 = 212° F.

(E) 1. 212° F into °C
2. Add 40 = 252
3. Multiply by 5/9 = 140
4. Subtract 40 = 100° C.

Occasionally an engineer says "But how am I going to remember whether you add or subtract 40 first." After **using** the rule a few times you remember it. If you do forget go back and convert 100° C to 212° F.

This idea was submitted by Art Whistler, the Fluor Corp., Ltd., Los Angeles.

Call on Rhodia "Odor Engineering" to solve your malodor problems in plant or product

Rhodia Inc. is the world leader in industrial odor control and reodorization technology and a primary producer of industrial aromatic chemicals. It offers fully qualified consultation service anywhere in the United States without cost or obligation.

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60 East 56 St., New York 22, New York
Gentlemen:
Please send me Rhodia literature.
My problem is: (please give specifics)

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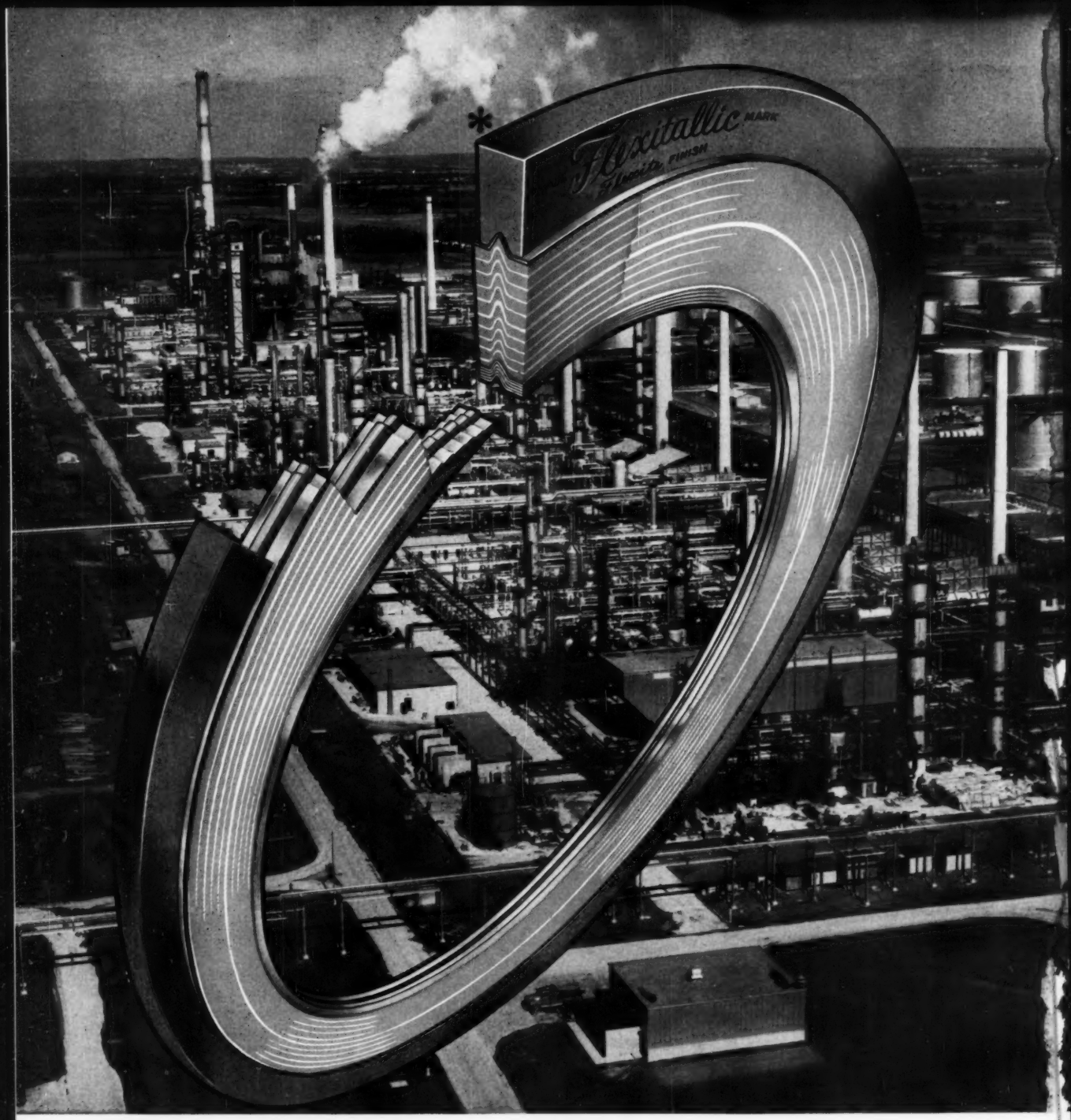


End corrosion in gasket inventory

The gold Flexite Finish* for the metal gauge rings in Flexitallic Compression-Gauge Gaskets is new. It is highly corrosion resistant when exposed to severest weathering in open construction projects or in stock. The Flexite Finish provides for ease of identification and a clean, long-lived installation. Write for samples.

FLEXITALLIC GASKET CO., 8th & Bailey Sts., Camden 2, N. J.
Representatives in Principal Cities

TRADE *Flexitallic*® MARK
SPIRAL-WOUND GASKETS
WITH *Flexite* FINISH

*The gold Flexite Finish is a development of the Flexitallic Gasket Co. (Originators of Spiral Wound Construction) – Register applied for on both name and color. Flexitallic Blue is our exclusive blue-dyed Canadian asbestos filler. Look for the blue and gold color combination as the mark of Flexitallic quality.

Who's Building...

Pemex—A Sleeping Giant Rises

More and more expansion is the only answer to Pemex's struggle to keep up with Mexican demand

Clayton A. Umbach, Jr.
Petroleum Refiner Staff

Guided by sharp, energetic engineers, Petroleos Mexicanos, the nationalized Mexican oil empire is rapidly becoming the most important single factor in the Mexican economy. Gone is that one-time feeling of *manana* (we can do it tomorrow) replaced by a sense of urgency to complete one task and start another. These are the impressions received after traveling more than 5,000 miles in Mexico, and studying Pemex operations from the dusty town of Reynosa near the Texas border to the tropical setting of Ciudad Pemex down by Guatemala—and from talking with Pemex workers from fresh, young engineers to the director general, Pascual Gutierrez Roldan.

But this feverish existence is certainly justified as Pemex finds itself in the enviable position of barely being able to keep up with an ever-increasing demand for more and more energy. Energy to feed new steel mills—energy to heat dozens of cities—energy to satisfy the cravings of a stronger and more industrialized Mexico.

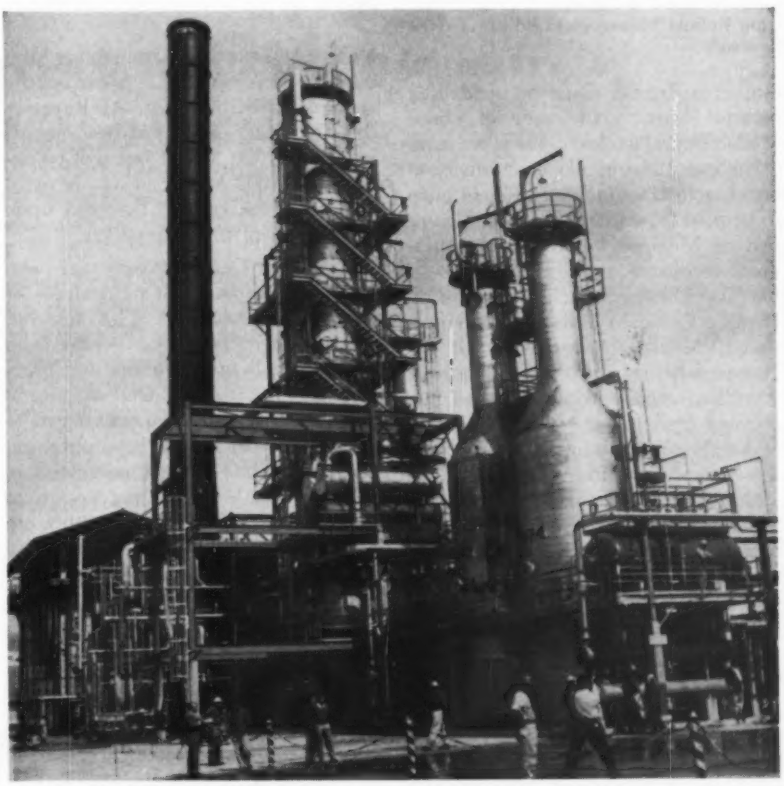
It is possible to get some idea of the extent of this demand by considering that the need for gasoline and distillate is increasing 7.5 percent a year in Mexico and an amazing 12 percent a year in the Mexico City area. As a result, Pemex refineries must run at full capacity to keep up with today—and expand considerably to prepare for tomorrow.

Refinery Building. Present refining capacity for the nation stands at 348,500 bpd which includes the spanking new $45 million, 135,000-bpd Ciudad Madero plant at Tampico which just went on stream in March. But Pemex is not concerned with just hiking capacity—as this plant was put into operation, three smaller, less efficient Tampico-based plants with combined capacities of 93,000 bpd were taken out of commission.

Other refinery expansion is being carried on with the construction of a new 15,000-bpd topping unit at Poza Rica, a 50,000-bpd topping unit at Minatitlan, and a 40,000-bpd topping unit at Salamanca which will double the size of that plant.

Once these units go on stream, Pemex officials feel they will have outstripped the demand for at least a few years. At that time they will be in a good position to offer custom processing to foreign interests—probably Latin American crude for Latin American markets.

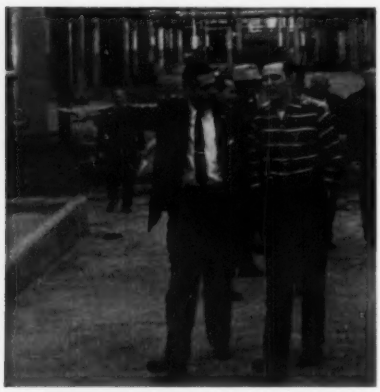
The monetary momentum for this expansion was provided by Pascual



Spanking new Ciudad Madero refinery adds 135,000-bpd capacity.

Boxscore of Pemex Construction

Project Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Engineering, Construction
Minatitlan	Anhydrous Ammonia	200 Tons	$8,000,000	Under Constr.	Mid. 1961	Fluor
	Crude Unit	50,000 bbls.	$23,000,000	Under Constr.	Mid 1961	Flour
	Cat Reformer					
	BTX Plant	4,800 bbls. Aromatics				
Salamanca	Anhydrous Ammonia	200 Tons	$8,000,000	Under Constr.	Late 1961	Lummus
	Topping	40,000 bbls.	$13,000,000	Under Constr.	Late 1961	Lummus
	Cat Reformer					
	Grease Plant	25 Tons	$2,100,000	Engineering	Mid 1961	McKee
Ciudad Madero	Refinery	135,000 bbls.	$43,000,000	Operating	March 1961	McKee
	Cat. Cracker	110,000 bbls.				
Poza Rica	Topping	15,000 bbls.	$5,000,000	Under Constr	Mid 1961	McKee
Atzcapozalco	Polyethylene	25,000,000 lb./yr.	$8,000,000	Engineering	Late 1961	Simon Carver McKee
Reynosa	Exp. Absorption Plant	6 MMcf	.....	Planning	.....	.....
Ciudad Pemex	Exp. Absorption Plant	7 MMcf	.....	Planning	.....	.....



Pemex's assistant manager of refining, (left), Ing. Cesar Baptista shows Axcapotzalco plant at Mexico City to Petroleum Refiner Management Editor Clayton Umbach.

Gutierrez Roldan when he negotiated foreign loans to the tune of about $128 million last year. However, capital expenditures in all Pemex divisions far exceeds this amount, and will have to be paid for with more foreign loans, private Mexican capital and equipment credits. A portion of this could have been met recently when Russian Deputy Premier Anastas Mikoyan visited Mexico. After touring the Pemex facilities, he offered a loan of 1 million credits with which to buy Russian equipment. It was refused.

Another indication of the status of the Pemex operation is the size of the 1960 Pemex budget which amounts to 8 billion pesos ($640 million). This is almost as large as the annual budget for the entire remaining federal government which amounts to only 10 billion ($800 million).

Octanes Steady. As the only supplier of gasoline and petroleum products, Pemex does not have to increase octanes because of competition or consumer demand. As a matter of fact, until recently Pemex offered three octanes at the pump, 70, 80 and 90, but in discontinuing the 70-octane raised cries of protest from many consumers.

Super Mexolina, the 80-octane which sells for around 26 cents a gallon, accounts for about 93 percent of the volume sold. The other grade, 90-octane Gasolmex, is available but has not yet achieved popularity. This is particularly true in the Mexico City area where the altitude provides motorists with a slight octane boost. As for the future of octanes in Mexico, some officials feel that the two grades will gradually rise to 82 and 95 respectively, while others feel a new third grade of about 95-octane will be added.

Natural Gasoline. Pemex has also donned its seven-league boots on the natural gasoline front. At Reynosa, the 400 MMcf per day plant is operating at just 300 MMcf but will be expanded to 600 MMcf to supply natural gas to the city of Torreron upon completion of a new pipe line.

The giant Ciudad Pemex plant was built to treat the rich natural gas of the Jose Colomo field. This field has an extremely large gas reserve and gets two gallons of butane and gasoline per 1,000 cubic feet of natural gas. It is presently being enlarged to 700 MMcf per day to supply dry gas for a pipe line being constructed to Mexico City with an extension to Salamanca. This line will supply energy to 10 cities along the way, including the industrial Mexico City era.

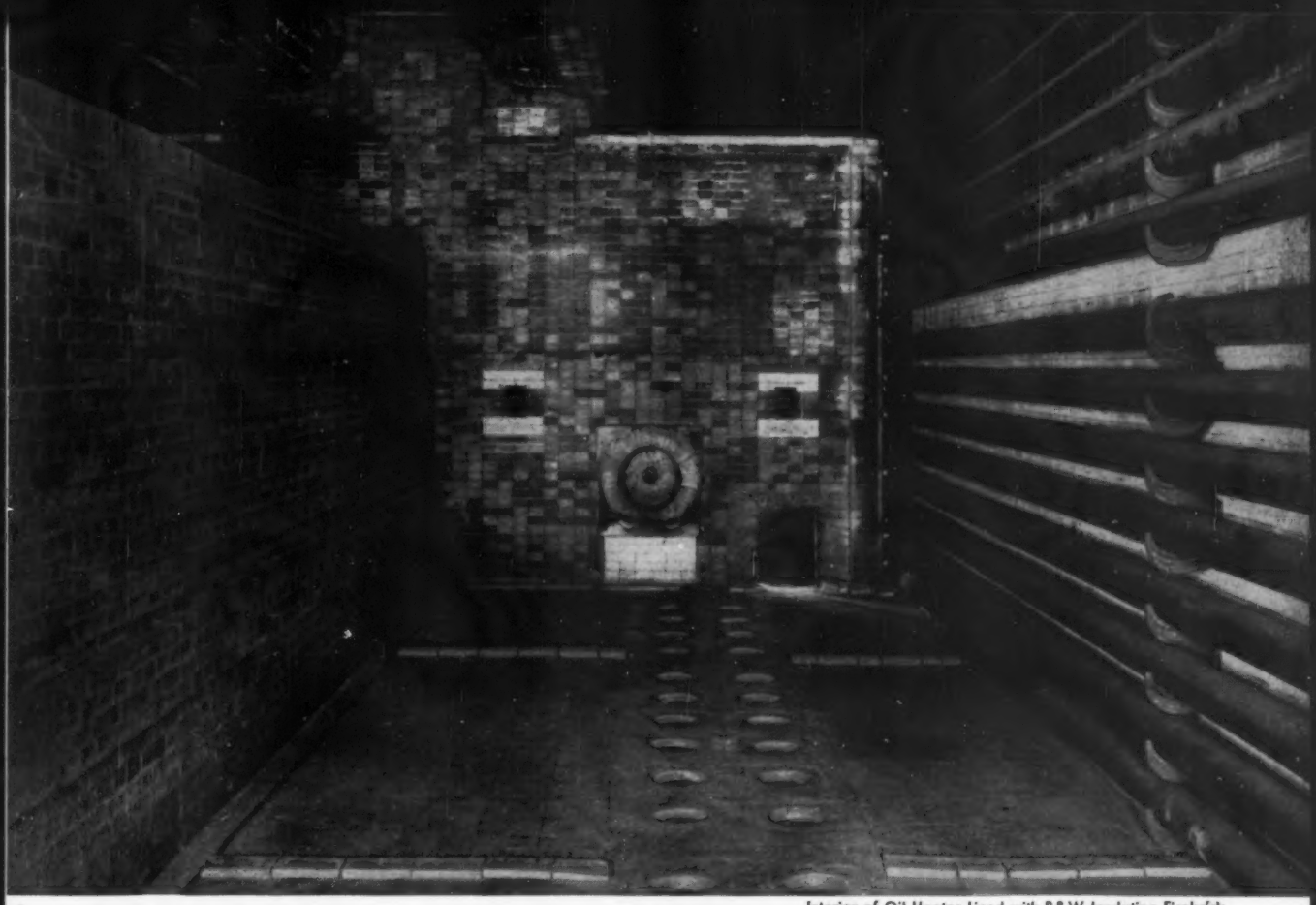
A third natural gasoline plant is located at Poza Rica and has a capacity of 240 MMcf per day but is now running only 185 MMcf. From this comes 150 MMcf per day of dry ethylene and methane, 2,300 barrels of propane and 5,100 barrels of natural-gas butane.

Petrochemicals. Pemex has come up with a list of basic petrochemicals which will be manufactured only by Pemex. However, private industry is welcome and even encouraged to build in Mexico to produce other petrochemical products. It is thought at the present time that Grace Chemical is considering building a urea plant, while Phillips is considering investing in carbon black facilities.

The first phases of the fledling Mexican petrochemical industry are located in the Azcapotzalco refinery in Mexico City. This consists of a plant that recovers 25 tons a day of sulfur from refinery gases and another plant that produces 45 tons a day of dodecylbenzene for the private Mexican detergent industry.

It is also at this refinery that a high-pressure polyethylene plant using the ICI process will be built. Engineering is being done by Arthur G. McKee and Simon Carter companies, and completion is slated for late '61. Also high on the list of Mexican petrochemicals is anhydrous ammonia with two plants already under construction. Other petrochemical projects are listed in the table.

One issue that concerns many officials, particularly those who are concerned with equipment buying, is that American equipment manufacturers are pricing themselves out of the Mexican market. American equipment and know-how is extremely popular with Pemex—this is evident just from walking through these plants. And as a matter of record, they are even willing to pay a premium for this equipment to insure U.S. reliability and service—but only up to a certain point. As one high refining official put it, "we are willing to pay as much as 10 percent more for American equipment, but when it goes higher than that we will place our orders elsewere."



Interior of Oil Heater Lined with B&W Insulating Firebrick.

B&W Refractories stay on stream

Long refractory life, low furnace maintenance, and dependable service result from the use of B&W Refractories. B&W offers a wide line of *specialized* refractories *engineered* to give you maximum furnace availability and economy.

Naturally, the refractory selected depends on the specific service. B&W Insulating Firebrick, for example, serve a dual role. First, these durable, lightweight IFB are most efficient insulators, and second, they withstand direct exposure to furnace heat. This means . . .

REDUCED CONSTRUCTION COSTS—The lightweight and high insulating value of B&W IFB combine to lower material costs and simplify furnace design. Because they withstand furnace heat, they eliminate the need for dense refractory constructions backed up with insulating materials. This, together with lightweight, means thinner, lighter wall constructions, often providing savings in structural steel and foundation costs.

REDUCED OPERATING COSTS—The high insulating value of B&W IFB means savings in everyday operation. Per inch of thickness, B&W IFB provide more insulation than any other refractory lining. Less heat is lost, casing temperatures are lower, working conditions are improved and efficiency is increased.

Furthermore, since B&W IFB are light in weight, they store and conduct less heat. Heavy refractories retain heat; in the event of forced shutdown, they can cause burn-out of expensive alloy tubes, where used. The low quantity of heat stored by B&W IFB can be quickly dissipated, thus protecting these expensive tubes.

This low heat storage also permits faster heating and cooling. This means quicker access to the furnace in the event of emergency shutdown. Your maintenance crew can get in the furnace sooner and get it back on stream faster.

Consult your B&W Refractories Representative for assistance with your refractories problem or write to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N. Y.

B&W

THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

R-628

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

Protected by L. W. Blazecrete—this structure was virtually undamaged by 2 to 6 hours of *direct* flame exposure

Protected by Johns-Manville L. W. Blazecrete . . .

vital equipment is undamaged by 3 days of explosive fire!

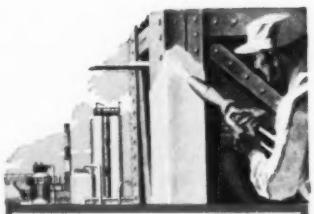
AFTER MORE than seventy hours of fire and explosion had spread from storage tanks to one of the world's most modern thermofor catalytic plants, damage was estimated at nearly 8 million dollars.

Yet the flames didn't destroy the entire plant. Vital equipment, key structural members and control areas . . . made fire safe by J-M's L. W. Blazecrete®. . . were virtually undamaged. This simple, low-cost protection paid for itself countless times over by providing an effective shield against 2 to 6 hours of direct flame exposure.

In your plant, too, Johns-Manville L. W. Blazecrete can save you money . . . for fire control and for lining high-temperature equipment.

A hydraulic-setting refractory—Johns-Manville L. W. Blazecrete is quickly, easily applied to equipment and structural members . . . and to linings of high-temperature equipment. For troweling, just mix L. W. Blazecrete with water as you'd mix ordinary concrete—then slap trowel in place. When gunned, L. W. Blazecrete adheres readily with a minimum of rebound loss. Whether used for fire protection or for linings—L. W. *Blazecrete lasts!*

Find out more about this newest of fire protection ideas, and about the application of L. W. Blazecrete throughout the petroleum industry. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

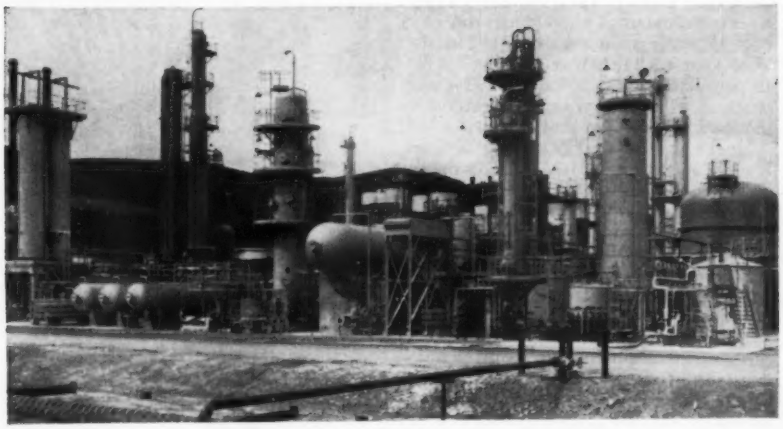


Gunned in place or slap troweled L. W. Blazecrete is the ideal material for refractory linings. It gives you an unusually strong, dense and homogeneous lining . . . ready for use within 24 hours.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

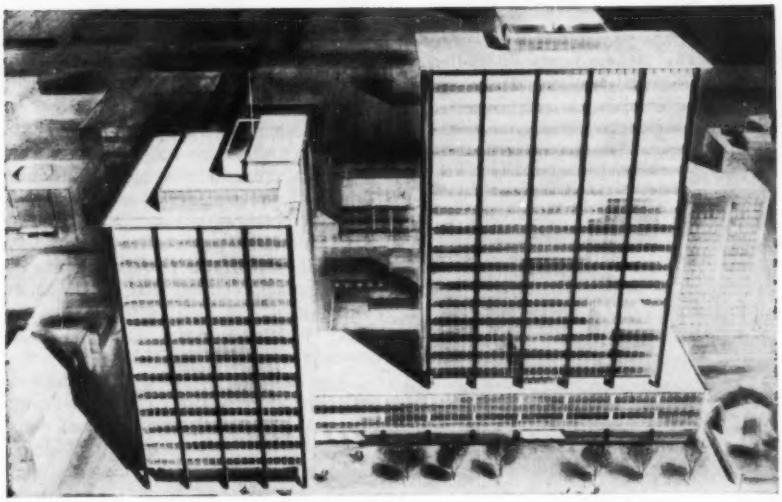
Building . . .



Big California Alkylate Plant for Oronite

Oronite Chemical Co. has started full-scale production of an improved detergent alkylate from a newly completed plant in Richmond, Calif. Though capacity figures were not revealed, the plant is said to be the "largest detergent polymer facility in the world." The multi-million dollar plant, under construction for 18 months, will produce detergent polymer, using a new process developed by Oronite's research affiliate, California Research Corp. The polymer will be processed into detergent alkylate to be sold as a base material for detergents.

Oronite reports that the new detergent alkylate's "improvement" stems from the product's increased molecular weight. The alkylate molecule's average carbon side chain is made up of 13 carbon atoms —significantly longer than molecular-chain structures found in conventional alkylates. It is the longer and heavier molecule, primarily, that prompts greater foaming and improved detergency.



Construction will commence immediately on a 14-story addition to Calgary's Elveden House project, for British American Oil Co., Ltd. The new office building will be named the "British American Oil Building" and will permit the consolidation of 750 B-A employes. Completion is scheduled for September 1961.

United Carbon Co. plans to construct a new company center on the outskirts of Houston. The $2.5-million project will include three buildings to house most of the company's research and development personnel. Included will be a lab with polymer development facilities.

Hooker Chemical Corp. and Atanor, Compania Nacional para la Industria Quimica, S.A.M. of Argentina plan to build a new jointly owned phenol plant in Argentina. A new company, Duranor, Industrias Quimicas Sociedad Anonima Industrial y Comercial, was

Choosing an Antioxidant?

DALPAC® 4 SAVES YOU MORE

Refinery customers have found that, in comparison with other inhibitors, Dalpac 4 (Hercules 2,6-di-tert-butyl-p-cresol) saves up to three dollars on every thousand barrels of gasoline produced. Dalpac 4 inhibits gum formation, stabilizes gasoline color, and helps maintain engine cleanliness. Refiners have also found it to be excellent in turbine and transformer oils where it prevents deterioration, and does not affect electrical properties.

For additional information write:

Oxychemicals Division
Naval Stores Department
HERCULES POWDER COMPANY
900 Market Street
Wilmington 99, Delaware

N059-5R

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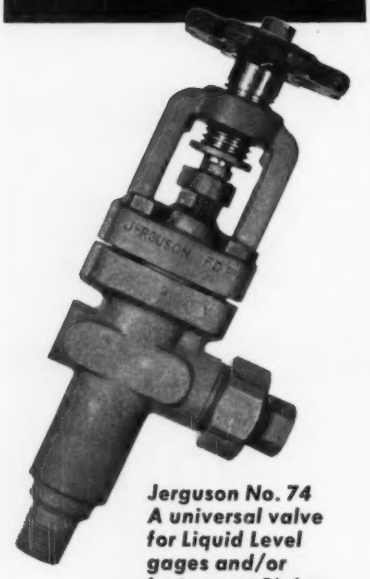
Here is a NEW
Jerguson
ALL-PURPOSE ANGLE VALVE



Jerguson No. 74 A universal valve for Liquid Level gages and/or Instrument Piping and General Use

This unique New Angle Valve has unusual advantages. A universal valve, ideal for liquid level gages . . . simply add our pipe plug with integral bleed (No. 74G) for the ideal valve for instrument piping and general use.

Combines Advantages of single-piece forged body and bonnet flange, simplified OS&Y bonnet and reciprocating stem in one valve.

Forged yoke supports stem away from valve body; separate forged gland-follower bears on packing, independent of yoke. Stem thread outside, not affected by temperature or liquid. Stem works freely, no chance of freezing.

Reciprocating Backseating Stem: Works in to-and-fro motion with no rotating action; gives perfect seating, eliminates wear from galling. Backseating eliminates packing contamination from liquid; can be repacked under pressure. Teflon seating available.

Write for catalog sheet on Jerguson No. 74 Valve.

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Gages and Valves for the Observation of Liquids and Levels

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Building . . .

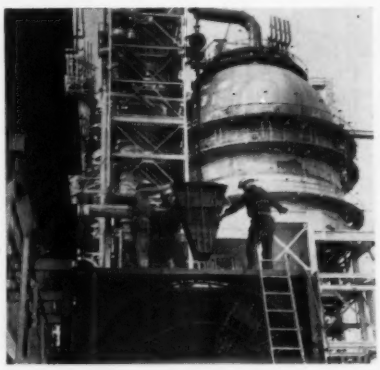
formed in January 1960, for this purpose. Its establishment as a manufacturer, however, depends upon successful negotiation of a loan to Duranor by the Export-Import Bank, Washington, D.C., for purchase of U.S. equipment. A decision by the Bank is expected shortly.

Under a basic agreement between Hooker and Atanor, Hooker has a minority interest initially with an option, exercisable within a year from approval of the bank loan, to acquire enough Duranor stock from Atanor to bring Hooker's interest in Duranor to as much as 50 percent. Plans call for building the Duranor facility at one of Atanor's two established plant locations. Construction is expected to begin in July, with completion within two years. Duranor will produce 25 metric tons per day by the newly developed Hooker phenol process.

Only one small phenol plant currently exists in Argentina. Phenol from the new plant will be merchandised generally as well as sold to Plasticos Atanor, an Atanor subsidiary, as a material for production of phenolic resins and molding compounds. Also, some monochlorobenzene will be sold. Besides phenolics, Atanor manufactures caustic soda, chlorine, sodium hypochlorite, hydrogen peroxide, benzene hexachloride, DDT, 2:4-D, toluene, xylene, benzene, chlorobenzenes, methanol, formaldehyde, and other chemicals.

Esso Standard Refinery Gets New Air Preheater

At the Bayway refinery of Esso Standard Oil Co., a new furnace installed in the largest fluid catalytic cracking unit



has been equipped with an air preheater. In the picture, one of the horizontal preheater's cold and elements (weight 1,000 pounds) is being lowered into position. Operating on a continuous regenerative counterflow principle, the preheater will preheat combustion air by recovering heat from the furnace's exit gases. The installation is justified mainly on "reduced fuel costs."

Asia Oil Co., currently in the process of merging with Maruzen Oil Co.'s subsidiary, North Japan Oil Co., plans to borrow $5 million from Cie. Francaise

When four or more pairs of thermocouple extension wires are needed, SERV-RITE thermocouple extension cable will reduce installation costs several ways. It takes considerably less time compared to pulling individual pairs of wires through conduit. Cable also permits the use of much smaller conduit than for the same number of individual wires. It can be hung without conduit, or installed in open trough or by direct burial.

The cable, as well as each conductor, is color coded. Also, each pair of wire is marked for quick identification.

Cables with multiple pairs of four or more conductors of the commonly used types are carried in stock.

Write for Bulletin No. 1200-3
for specifications and data on SERV-RITE thermocouple extension cables.

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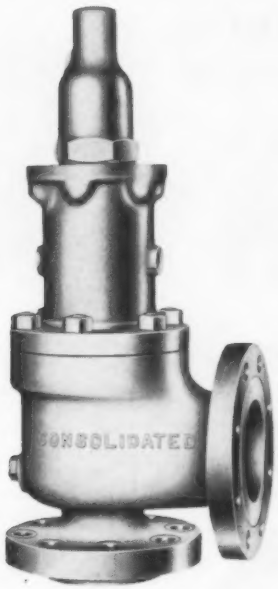
seal

CONSOLIDATED SAFETY RELIEF VALVE'S Sealing Bellows protects against damage from contaminants, corrosion, or viscous fluids

saves



Consolidated Safety Relief Valves are available in both Balanced Bellows and Standard designs. The Standard type has an eductor tube that effectively removes bonnet pressure.

Balanced Bellows Type Consolidated Safety Relief Valves have a durable, two-ply stainless steel Sealing Bellows that isolates and protects working parts from destructive elements in the lading fluid.

The bellows is balanced with the seating surface. Even with superimposed back pressure in the relieving system, valve performance is consistently stable and dependable. The bellows does not affect the high capacity of the valve, nor does it require change in set pressure. Even the blowdown adjustments are limited.

Additionally, Consolidated Safety Relief Valves now offer a no-leak tightness maintained by a resilient "O" Ring Seat Seal retained in the valve disc. This Seal assures tightness at operating pressures far closer to set pressure than with metal-to-metal seats alone, yet does not carry the seat load imposed by the spring. The Seal also takes piping strains much better than all-metal seating.

The Sealing Bellows and "O" Ring Seat Seal are typical of the extra quality built into Consolidated Safety Relief Valves to assure absolute protection for personnel and plant. These fine features plus flat seating and single ring construction also eliminate many maintenance problems and costs. Write for Catalog 1900 and Bulletin 1940.

MAXWELL M&M MANNING & MOORE INC. TRADE MARK

CONSOLIDATED SAFETY RELIEF VALVES

A product of

MANNING, MAXWELL & MOORE, INC.

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Aeromaster
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BLADES

Blades can
be installed
after hub is mounted
on drive shaft

Performance, construction, and price make this the "best buy" in industrial fans! Delivers more CFM with *less* H.P. Features a ductile iron hub, removable blade retention caps, heat treated aluminum alloy blades with constant chord width and flanged ends. 4, 6 and 8 bladed fans available in 54" to 120" diameters. Maximum tip speed is 15,000 ft./min. Easy to install . . . easy to maintain. For complete details, write: KOPPERS COMPANY, INC., 5105 Scott Street, Baltimore 3, Md.

KOPPERS Aeromaster Fans

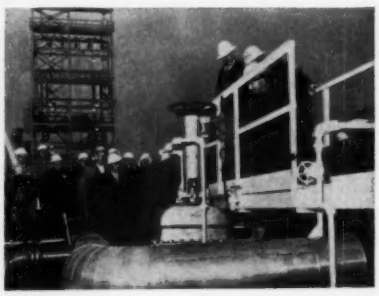
Engineered Products Sold with Service

Building . . .

des Petroles for expansion. The Japanese independent will borrow the money for seven years at six percent interest. Asia Oil's Yokohama refinery will be reconstructed and expanded to 30,000 bpd at a cost of $20 million. The company has signed a nine-year contract for three million tons of crude oil.

Big Holland Refinery On Stream for Esso

Esso Standard Oil Co. has completed construction of its new $5-million refinery at Spijkenisse, Holland, near Rotterdam. Built by Badger N.V., the 95,000-bpd



plant came on stream at a gathering of refinery personnel and Spijkenisse citizens. Construction of the grass roots project took about 18 months. The refinery will serve the Dutch market, and about 50 percent of the production will be exported to Germany and Scandinavia. The big plant employs Esso's new process for catalytic reforming. It features airfin cooling systems, total electronic instrumentation, and two large piers which can handle 50,000-dwt tankers.

AviSun Corp. has awarded the engineering contract for a 100-million-pound-per-year polypropylene plant to Bechtel Corp. Engineering plans call for the plant to be located in the Eastern United States. Although the site for the proposed plant has not been finally selected, AviSun has narrowed it down to just a few possibilities. The company began operating a 20-million-pound-per-year polyproylene plant at Port Reading, N. J., last September.

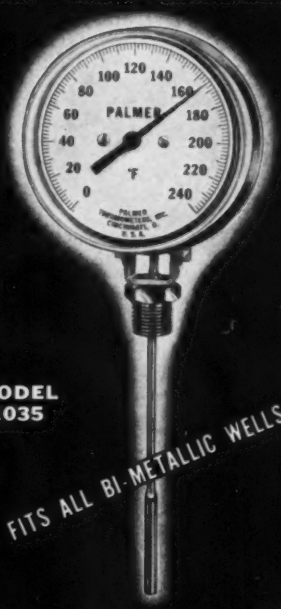
The Dow Chemical Co. is planning to up its styrene monomer capacity to 800 million pounds per year. The expansion, to be split between Freeport, Texas, and Midland, Mich., facilities, is to be completed in the last quarter, 1960 or first quarter, 1961. Through the expansion project, Dow will retain its position as the nation's number one styrene monomer producer.

American Chemical Corp.'s new chlorinated hydrocarbon facility is on stream at Long Beach, Calif. Ethyl chloride, vinyl chloride, and ethylene dichloride are being produced from basic raw materials for the first time on the West Coast in the new $7-million plant. A fully instrumented control center com-

Outstanding Accuracy

PALMER

Dial Thermometer



Check these functional features

- Direct-drive Bourdon Coil with a filled system for longer lasting accuracy.
- Stem can be placed at any desired angle and case can be rotated to most readable position.
- External calibration for zero setting.
- Unaffected by stem alignment.
- Accurate to one scale division.
- No sticking at any temperature.
- Non-corrosive case.

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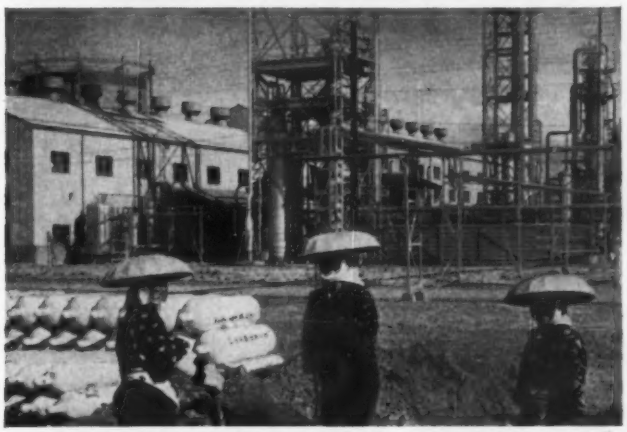
AMMONIA

NEW CHEMICO PLANTS TO BOOST WORLD CAPACITY 12½%



- 20 NEW PLANTS IN 7 COUNTRIES
- 8 NEW PLANTS IN THE U.S.A.
- 1,113,000 TONS PER YEAR

Since the first months of 1957, 13 new Chemico ammonia plants have been completed and put into operation. Another 7 Chemico plants are under construction or in the engineering stages. The design capacity of these 20 plants totals more than 1,000,000 tons per year.

Chemico's versatility in ammonia plant design is evidenced by the variety of raw materials on which these plants are based. While natural gas was the most common, crude oil, fuel oil and coke oven gas were also used. Regardless of feed stock, however, all thirteen of the operating plants were completed on schedule and started up without significant difficulties or delays. One plant, designed to produce 150 tons per day, took less than ten months to build, from initial go-ahead to completion of a satisfactory test-run.

This outstanding record in the ammonia field is just one of the reasons why chemical and petroleum companies all over the world continue to call on Chemico when they require ENGINEERING AT ITS BEST.

CHEMICO
CHEMICAL CONSTRUCTION CORPORATION
525 West 43rd Street, New York 36, New York

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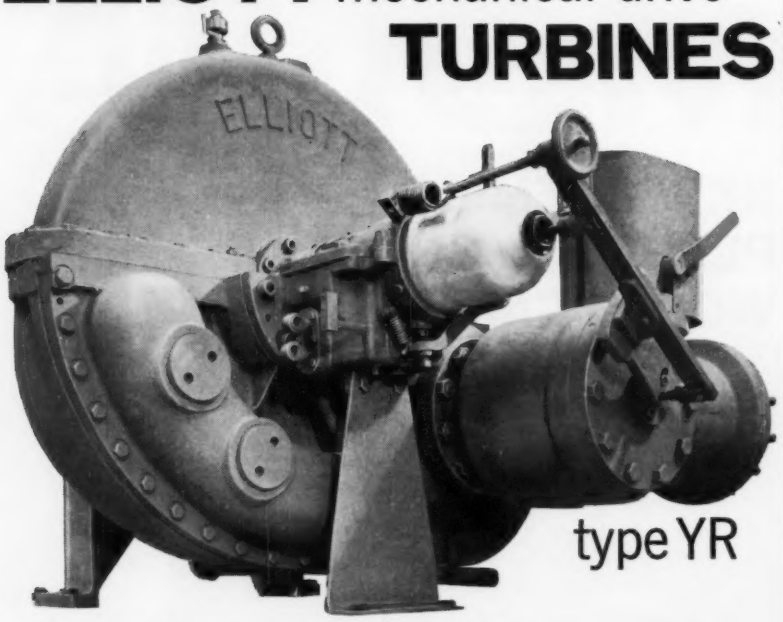
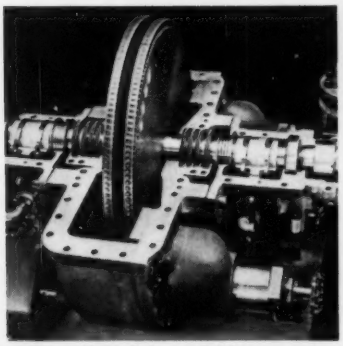
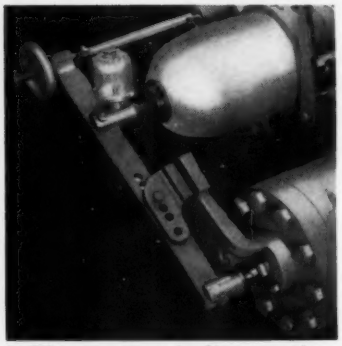
ELLIOTT mechanical drive TURBINES



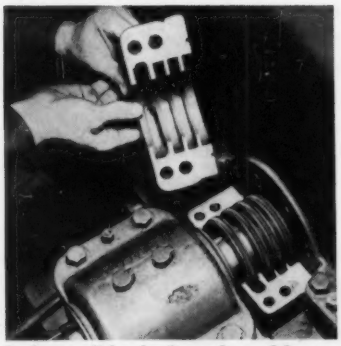
These features mean long life, easy operation



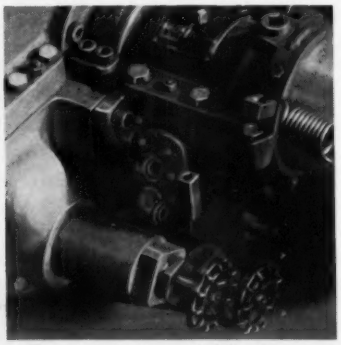
1. Smooth and dependable operation at all operating temperatures is assured by the precise alignment of the dynamically balanced shaft.



2. The governor is direct-acting, simple and weather-proof. Separate trip gives over-speed protection. Easily reset against line pressure.



3. Accessible shaft-seals and bearings simplify maintenance and inspection. Covers are readily removable without disturbing the casing.



4. Economy at partial loads is secured by the steam-saving hand valve with pilot, which can be opened against full steam pressure.

ELLIOTT Company
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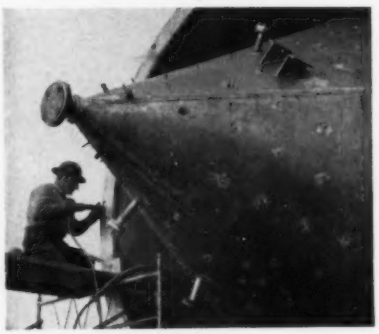
HO-2

Building . . .

bined with an experienced staff of production personnel has resulted in the manufacture of products having a quality level "in excess of industry requirements," says the company. American Chemical is jointly owned by Stauffer Chemical Co. and Richfield Oil Corp. Laboratory, plant and offices are all in Long Beach.

New Urea Crystallizer Is Installed by SunOlin

A new crystallizer that will produce 55½ tons of urea crystals a day is being installed at SunOlin Chemical Co.'s urea



plant at North Claymont, Del., which will be completed this year. The crystals will be used for fertilizer applications and special chemicals. The plant will also produce 166½ tons of urea prills a day for urea-formaldehyde resins and other industrial uses.

Federated Co-operatives, Ltd. has awarded the major part of a $2.7-million contract for a construction program at Regina, Sask., to Procon (Canada) Ltd. The contract is for erection of a 3,000-bpd Platformer and 6,000-bpd middle distillate Unifiner, to provide more flexibility in production by enabling larger quantities of high-demand fuels to be made from lower-demand products.

Other construction and renovation projects are to be performed by the refinery's construction and maintenance crews. These include preparation of the site for new units, erection of a larger water cooling tower, major changes in pipe lines, electrical equipment and sewers, enlargement of the control room, and modifications to crude oil distillation units. Procon has commenced engineering work. Actual construction is to begin immediately with a target date for completion set at December 1960.

Gasoline of current octane ratings will be manufactured with a reduced amount of tetraethyl lead from straight-run gasoline by the Platformer. The unit can also produce gasolines of even higher octane ratings expected to be required in the future. Of equal importance, hydrogen is produced as a by-product of the Platformer. The middle distillate Unifiner will add a new process of hydrogen treating to upgrade intermediate products used to manufacture heater, diesel, and

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US RUBBER MATCHLESS #5 STEAM HOSE

3 Men . . . 3 Applications
One Hose

Safety
U. S. Matchless #5 Steam Hose has been used at a Phillips Petroleum refinery* since 1930, for thawing and firefighting.

Easy Handling
Here U. S. Matchless #5 is being used to remove spilled oil.

Economy
Warehouse boss at Phillips Petroleum inspecting a length of U. S. Rubber Matchless #5 Steam Hose.

Men like to work with U. S. Matchless® #5 because it's so lightweight, so flexible. Ordinary hose is hard to handle, can't take much dragging around. But the hose that's readily available, lasts longer, and satisfies the operators is the best investment. That's U. S. Matchless.

When you think of rubber, think of your "U. S." Distributor. He's the best on-the-spot source of technical aid, quick delivery, and industrial rubber products.

*Okmulgee, Okla.

US RUBBER

Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

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PRODUCT IMPROVEMENT WITH

PETRECO

EFFICIENT DESALTING is the first step toward PROFITABLE REFINING

Salt removal is now a routine operation in all modern refineries. With the need for effective desalting widely recognized, the main problem today is the selection of that equipment which will do the most efficient job at the least possible cost.

When you need new or additional desalting facilities, keep these points in mind:

■ ***The first electric desalter was designed and installed by Petreco engineers.***

This was nearly a quarter of a century ago. The subsequent years of solid, practical experience in dealing with (and solving) desalting problems all over the world now enable Petreco desalting to yield salt removals in the 98-100% range. The fraction of a cent per barrel desalting cost is saved many times over by the gains in refining efficiency resulting from a clean charging crude.

■ ***The first chemical desalter was designed and developed by Tretolite engineers.***

Tretolite chemical formulations were the first ever to be used in desalting. Tretolite desalting units are the only exclusively chemical desalters ever to be sold and installed in the refining industry and are currently used to desalt a million and a half barrels per day. In fact, every important development in crude oil desalting has resulted from the Petrolite research, engineering and development program.

YOU GET

98-100% SALT REMOVAL

WITH PETRECO ELECTRIC OR

TRETOLITE CHEMICAL DESALTING

Because Petreco offers both kinds of desalters, the company has no "axe to grind". This means that you get an honest and objective appraisal of the method best suited to your operation.

There is no other desalting equipment on the market today that can offer you comparable efficiency of design. The operating records from installations around the world *prove* it! There's no other company, either, that can offer you Petreco's fund of desalting technology or Petreco's rich background in this highly specialized field.

DT-60-1

PETROLITE CORPORATION

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NETHERLANDS: F. E. C. Jenkins, Hoefbladlaan 134, The Hague
TRINIDAD: Neal and Massy, Ltd., P. O. Box 544, Port of Spain

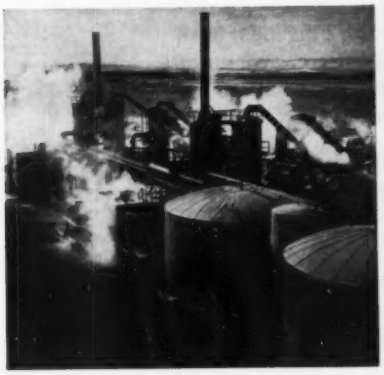
Building . . .

furnace fuels. Increasing demands for products of these types has made it necessary to install the Unifiner to ensure adequate quality of all products refined.

Signing of the latest contract marks the start of the fifth major construction and expansion program undertaken since the refinery started in 1933. Present capacity is about 16,000 bpd, and annual output capacity is about 160 million gallons of refined products.

Susquehanna Western Corp. Up With Sulphuric Acid Unit

A new sulfuric acid plant in Riverton, Wyo., constructed by Susquehanna-Western, Inc., subsidiary of The Susquehanna Corp., doubles the company—and



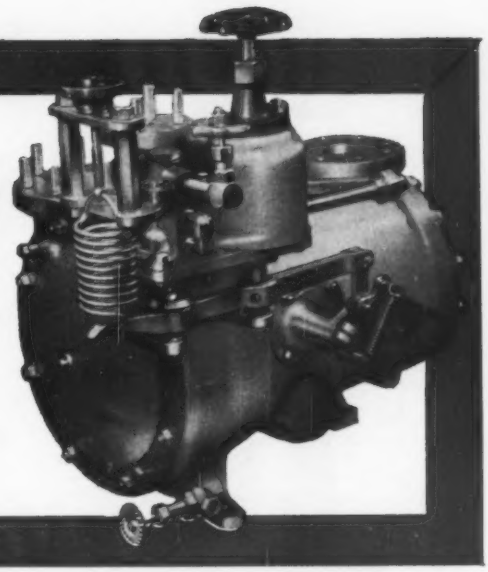
Wyoming's—sulfuric acid production capacity to 75,000 tons of acid per year. The additional facilities are needed, according to the firm, to meet a substantial increase in demand for sulfuric acid resulting in part from new ore processing mills in the area.

Union Carbide Chemicals Co. has awarded a construction contract to alter and revise plant facilities at Brownsville, Texas, to Brown & Root, Inc., Houston. Construction work will begin immediately and is expected to be completed early in 1961. The contract will result in expenditures of about $2.5 million in the Brownsville area, principally for labor. The Brownsville plant will be Carbide's eighth producing center. Among chemicals to be made are acetic acid, acetic anhydride, and methyl ethyl ketone. These chemicals will be made in large quantities. Carbide's third chemical plant in Texas is located on a 309-acre tract near Brownsville being leased on a long-term basis from the Brownsville Navigation District.

Texas-U.S. Chemical Co. has started an expansion program to increase the output of its synthetic rubber copolymer plant in Port Neches, Texas, by approximately 10 percent to 156,000 long tons annually. The company is jointly owned by Texaco, Inc., and United States Rubber Co. The expansion will primarily involve additional drying and carbon-black masterbatch production facilities. The need for enlarging these facilities was

Complete Pump, Turbine and Controls

COFFIN IND TURBO PUMPS



PACKAGED — integral design of the IND Pump results in a compact, highly efficient unit which mounts impeller and turbine wheel on a short, rigid shaft. The unit is equipped with complete controls for constant or differential pressure regulation.

APPLICATIONS — compact and highly efficient, the Coffin type IND Steam Turbo Pump is designed for General Boiler Feed or any other pumping service where medium volume and high pressure is required.

SPECIFICATIONS-

Capacities	to 180 GPM	Height 32"
Discharge Pressures	to 350 PSIG	Width 25"
Liquid Temperatures	to 300°F	Length 32"

For special installations these ratings may be exceeded.

Coffin Turbo Pump Co.
326 South Dean Street, Englewood, N. J.

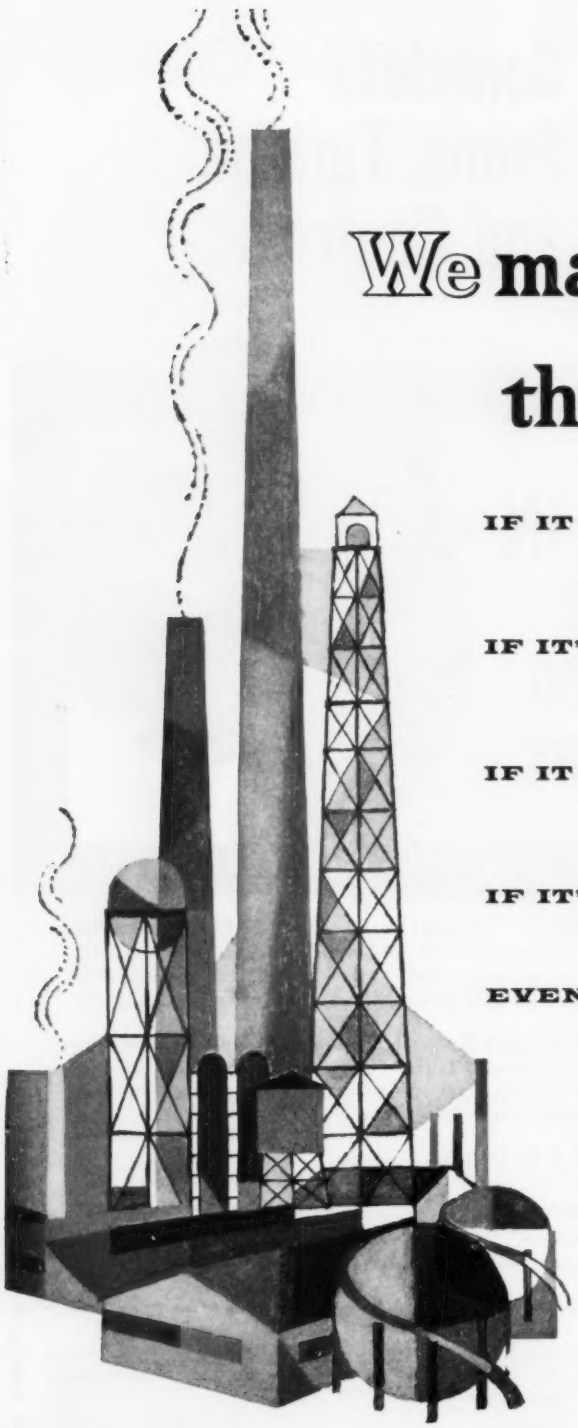
Gentlemen: Please send me illustrated booklet further describing the Type "IND" Pump.

Name _____
Position _____
Company _____
Street _____
City _____ Zone ____ State _____

fmc

COFFIN TURBO PUMP CO.
FOOD MACHINERY AND CHEMICAL CORPORATION
326 South Dean Street • Englewood, New Jersey
Agents in all Principal Cities • Cable Address: COFCO

For more data on advertised products, use Readers' Service Cards, last page.



We make the pumps that move it!

IF IT FLOWS... through pipelines, heat exchangers, cooling towers, evaporators, condensers, stills, boilers or other processing equipment . . .

IF IT'S LIQUID... gases, paints, molasses, lubricants, chemicals, foods, plant wastes, asphalt, fuel oils, solvents, fibrous trash or solids in slurries . . .

IF IT CIRCULATES... through cracking plants, refineries, canneries, paper mills, steel mills, packing plants, breweries, air conditioning systems or machine tools . . .

IF IT'S PUMPED... in or out of mines, sewers, construction sites, cofferdams, swamps, reservoirs or tank cars . . .

EVEN IF it's highly corrosive or volatile, viscous or non-viscous, hot or cold . . .

The Fairbanks, Morse line of pumps includes a type, size and capacity for almost any pumping requirement—and the power unit matched to drive it!

Pump sizes to 152 inches . . . capacities to 800,000 gpm . . . heads to 3000 psi.

(Electric motors that move the pumps: ½ to 10,000 hp... Generators, alternators and generator sets ½ kw to 3,500 kva.)

Fairbanks, Morse

PUMP AND HYDRAULIC DIVISION • KANSAS CITY, KANSAS

A MAJOR INDUSTRIAL COMPONENT OF FAIRBANKS WHITNEY CORPORATION, NEW YORK

Building . . .

created by increased demand for "homogenized" masterbatches of carbon black and butadiene-styrene synthetic rubbers commercially introduced by Texas-U.S. Chemical about two years ago.

Engineering design work is being carried out by the company's Engineering Department in cooperation with Tellepsen Petro-Chem Constructors. Construction is expected to be completed late in 1960. Full production from the new facilities is scheduled for early 1961.

Tidewater Oil Co.'s Danish subsidiary, Dansk Veedol, has awarded contracts for construction of a 20,000-bpd refinery at the Danish seaport of Kalundborg. Firms receiving contracts are Foster Wheeler, Ltd., of London and Societe Fives-Penhoet, Paris. Preliminary engineering work on the plant, the first crude oil refinery in Denmark, have begun, and it is to come on stream in September 1961. Total Dansk Veedol capital expenditures in Scandinavia are expected to be $24.3 million over the next two years. Marketing terminals for the Kalundborg refinery's products are under construction in Norway and Sweden. Dansk Veedol has obtained 550 acres at Kalundborg for the refinery and its attendant pier facilities. Design of the unit permits expansion to 40,000 bpd.

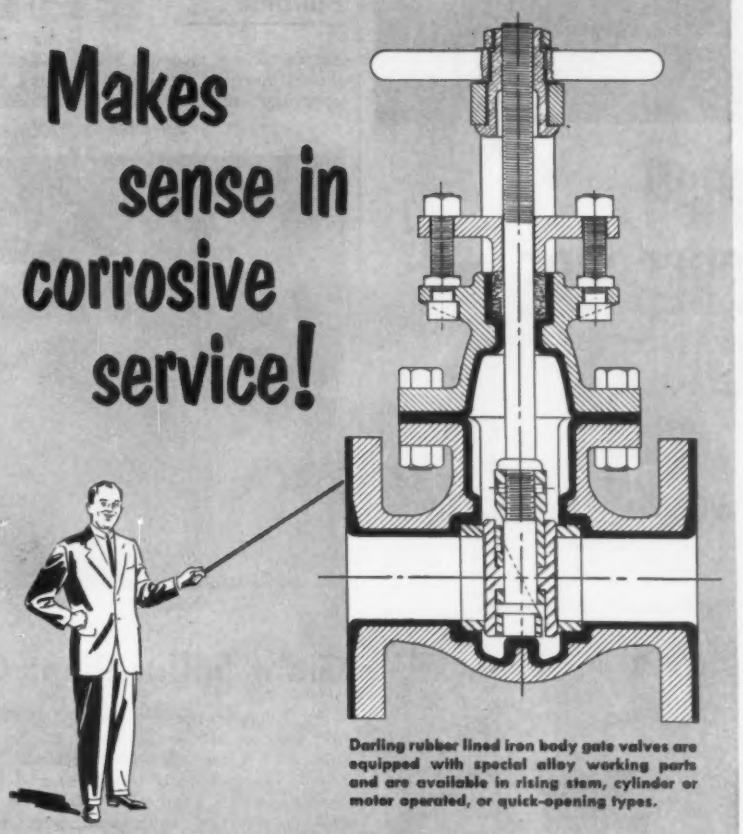
Collier Carbon and Chemical Corp. has named Leonard Construction Co. to furnish materials, engineer and design a Leonard-Monsanto contact sulfuric-acid plant at Los Angeles. The plant, which will have an initial rated production capacity of 250 tons of acid per day, will use spent alkylation acid, hydrogen sulfide and sulfur as raw materials. The unit is designed specifically to meet air-pollution regulations of the area. One of its unusual features is a mist eliminator which will be installed to control fume emission from the stack. The plant is scheduled for completion by late 1960.

The Standard Oil Company (Ohio) has started construction on a new carbon monoxide boiler at its Lima, Ohio, refinery. The CO boiler, designed by Babcock and Wilcox Co., involves an estimated capital expenditure of $1.5 million. Construction is to be completed by December.

The CO boiler will "reduce fuel costs and increase the steam production potential" at the Lima refinery. The fuel savings will be realized by "burning the carbon monoxide and recovering appreciable quantities of heat from the flue gas of the existing fluid catalytic cracking unit." The boiler will also be equipped to burn supplemental fuel—a mixture of refinery and natural gas.

Construction of this unit will allow the refinery to replace about half of the existing steam producing capacity, and run the remainder only as necessary to supplement the CO boiler production. With the flexibility to go to a high pressure superheated steam system in the future,

Makes sense in corrosive service!



Darling rubber lined iron body gate valves are equipped with special alloy working parts and are available in rising stem, cylinder or motor operated, or quick-opening types.

DARLING RUBBER LINED IRON BODY GATE VALVES

Problem: How to get away from costly, special alloy gate valves in handling corrosive fluids and still have long, trouble-free valve life.

Answer: For pressures up to 150 pounds and temperatures to 180° use Darling iron body gate valves with the permanently bonded hard rubber lining. They're giving outstanding service in job after job. Moreover, they have the Darling *fully revolving double disc parallel seat feature* that multiplies disc and seat life and assures tight closure longer . . . much longer!

Write for complete information on these exceptional rubber lined valves . . . or for data on other Darling gate valves including the range of alloys, types and constructions for ordinary or special services.

DARLING VALVE & MANUFACTURING CO.
Williamsport 31, Pa.
Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

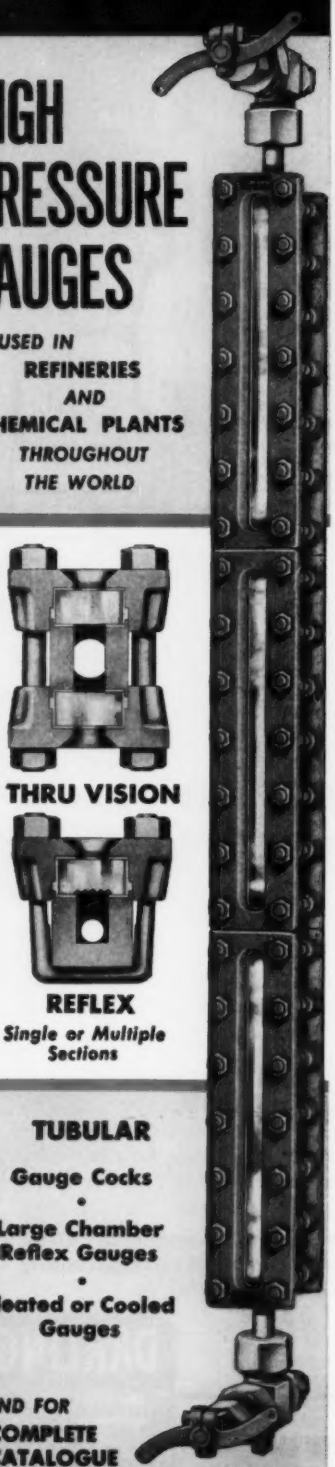
DARLING VALVES

For more data on advertised products, use Readers' Service Cards, last page.

Strahman

HIGH PRESSURE GAUGES

USED IN REFINERIES AND CHEMICAL PLANTS THROUGHOUT THE WORLD



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REFLEX

Single or Multiple Sections

TUBULAR

Gauge Cocks

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Large Chamber Reflex Gauges

•

Heated or Cooled Gauges

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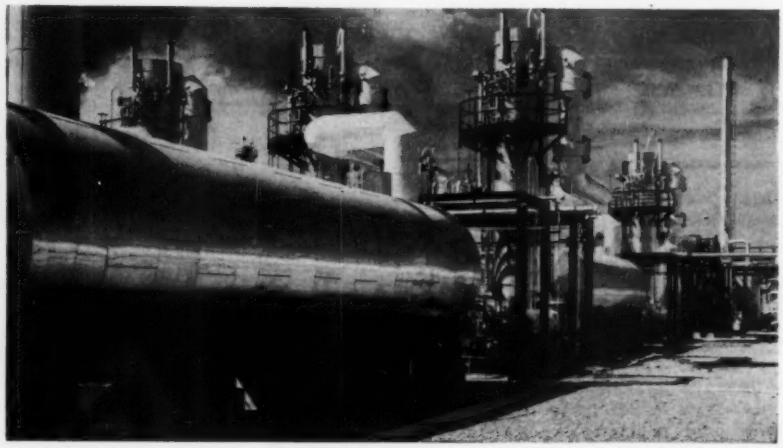
STRAHMAN VALVES, Inc.
NICOLET AVE., FLORHAM PARK, N. J.

Building . . .

the waste heat recovery boiler will enable the refinery to obtain lower fuel and operating costs for future expansion. A major item of the installation is a 48-inch flue gas duct to carry gas from the cat cracker to the boiler. The CO boiler will be located adjacent to the present boiler house, using existing feed water treating facilities.



Giant Sulfur Plant On Stream in France

A 1,000-ton-per-day sulfur recovery unit went on stream March 21 at the gas processing plant of SNPA (Societe Nationale des Petroles d'Aquitaine) at Lacq, France. Design, engineering, procurement, and construction supervision were performed by The Ralph M. Parsons Co. and S. A. Heurtey Co., Paris.

The new unit will be joined by its twin in a few months, bringing total processing capacity to 750 mmcf of raw gas per day, and sulfur recovery to 4,000 long tons per day. This is the largest installation of its kind in the world, the last two sulfur recovery units exceeding in capacity the largest U. S. and Canadian plants.

With abundant fuel at hand, a 125,000-kw electric-power plant is presently under construction. Existing fertilizer plants will be expanded, and the company looks for an increase in production of ammonia, methanol, acetylene, acetyldehyde, butanol, and other organics.

In heat value, the gas production of Lacq will be equivalent to about 6 million tons of coal. Lacq gas will reduce by about 10 percent the country's present import of energy-fuels. Gas is being piped

to Paris, Lyons and neighboring cities, with a 550 mile, 16 to 24-inch pipeline scheduled for completion late this year.

World's Largest Crude Unit for Amoco

The world's largest crude running unit will be constructed at the American Oil Co. refinery, Texas City, as part of a major capital improvement and modernization program. The program will include construction of:

- A 150,000-bpd crude unit, largest in the world.
- A new catalytic cracking unit with a fresh feed rate of about 47,600 bpd.
- A 14,600-bpd alkylation unit, which will include butane splitting and isomerization facilities. It will also be the world's largest such unit.

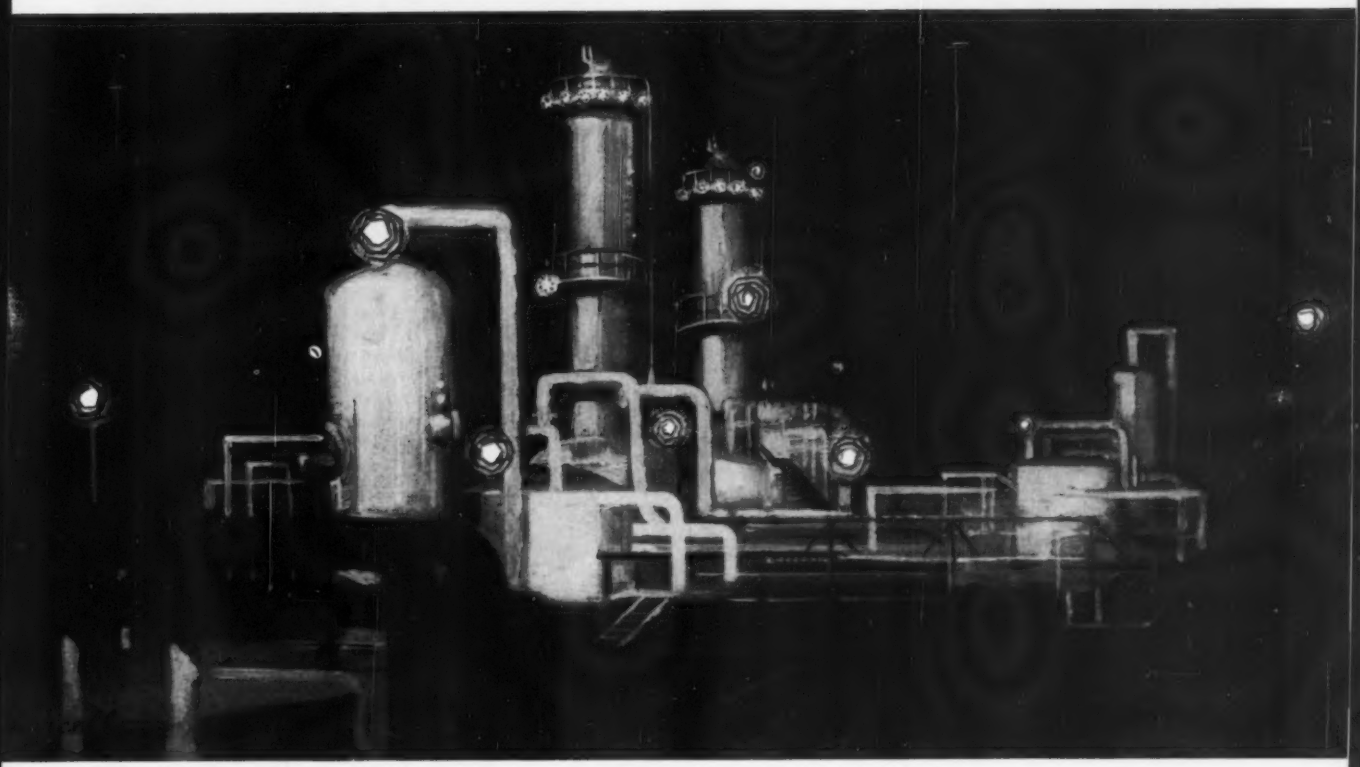
The three new units will replace six currently in existence, including three combination crude running-thermal cracking units, a polymerization unit, a power house, and the treating plants. The old units will be retired as the new ones come on stream. Eventually they will be scrapped.

While the new 150,000-bpd crude unit will add slightly to present crude-running capacity at the refinery, the moderniza-

For more data on advertised products, use Readers' Service Cards, last page.

A refinery never sleeps

Twenty-four hours a day, a refinery is in operation. Its hundreds of miles of tubular products are constantly subjected to high temperatures and tremendous pressures. In order to survive under conditions like these, the tube must be hand-picked for the job. And, that's where National Tube comes in. If you need advice in refinery tube selections, get in touch with National Tube.



Our experience in this field comes from more than 60 years of gathering information for the solution of refinery tube problems. And, we've used this data to develop 24 different seamless steel tube analyses—each one the answer to a specific set of refinery conditions. Other chemical compositions are also available in tubular products, and a wide variety of high temperature problems are under study.

National Tube's Mill Service Force, available for field consultation, will be happy to help you find the right alloy, at the right price, to meet your needs. Write to National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS and National are registered trademarks

Here are National Tube's two dozen different tube analyses:

Carbon	5 Cr, ½ Mo	17 Cr
Carbon ½ Mo	5 Cr, ½ Mo, 1⅛ Si	18-8
1 Cr, ½ Mo	7 Cr, ½ Mo	18-8 Ti
1¼ Cr, ½ Mo	8 Cr, ½ Mo	18-8 Cb
2 Cr, ½ Mo	8 Cr, 1 Mo	18-8 Mo
2¼ Cr, 1 Mo	9 Cr, 1 Mo	25-20
2¼ Cr, ½ Mo, ¾ Si	12 Cr	3½ Ni
3 Cr, 1 Mo	12 Cr, Al	5 Ni

"The world's largest and most experienced manufacturer of tubular products"

USS National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division · United States Steel Export Company, New York

VIBRATION ?

—in Piping, Vessels, and Structures

Send for Catalog 229A

HERE'S HOW to stop it—

BARCO

"VIBRASNUB"

TRADE MARK

HYDRAULIC VIBRATION SNUBBERS

BARCO'S new "VIBRASNUB" units *allow thermal movements*, but effectively restrict rapid vibration and momentary shock loads such as may cause dangerous stresses, annoying noise, or deterioration in many kinds of structural assemblies. No reactive forces, as with spring-type dampners. "VIBRASNUB" units act instantaneously and do not rely on deceleration of movement.

Typical applications include control and protection of high temperature piping and large diameter lines in steam plants, petroleum refineries, and process plants. "VIBRASNUB" units are available from Barco factory stock and are readily adaptable to economical field use.

Barco can provide engineering data to help you solve many vibration problems. Ask for information. SEND FOR CATALOG 229A.

for structural applications

These pre-engineered load-carrying units help eliminate need for complicated structural designing and the design of special struts, tie-rods, slides, or pin-and-clevis arrangements. They handle *both tensile and compressive loads* and are almost always lower in first cost as well as on a life-time basis. *For complete information, ask for Catalog 229A.*

FOUNDED 1928 BARCO PRODUCTS BACKED BY EXPERIENCE

BARCO MANUFACTURING CO.

542F Hough Street • Barrington, Illinois

Flexible Joints • Structural Products • Construction Equipment

In Canada: The Holden Co., Ltd., Montreal

Building . . .

tion program's purpose is to increase product quality and operating efficiency, rather than capacity.

The new crude still, larger by 10,000 bpd than a similar unit that went on stream at the Standard Oil Co. (Indiana) refinery at Whiting, Ind., last year will handle all non-asphaltic crude processing at the refinery. It will be a two-stage pipe still with a fractionation system having a capacity of 150,000 bpsd of crude. The old thermal cracking units destined for retirement are among the first built at the 26-year-old refinery.

Mitsubishi Petrochemical Co., Ltd. has named Stone & Webster Engineering Corp. to design and assist in the engineering and construction of a second ethylene plant. The petrochemical plant is to be located at Yokkaichi, near the industrial seaport of Nagoya and is scheduled for completion in 1961. S&W will provide design and other engineering services as well as assistance during construction and initial operations. Detailed engineering will be done in Japan. Materials and equipment will be supplied by Japanese industry and all construction work will be done by Japanese craftsmen.

In spring 1959, S&W completed the first ethylene plant for Mitsubishi at the Yokkaichi site. During Typhoon "Vera" last year this plant was under several feet of flood water, but suffered no damage except to a few pump motors. The new unit will include several engineering innovations and improvements in design, which have been developed since completion of the first plant. Cracking furnaces and acetylene removal facilities will be simplified. The furnaces will operate on both gas and oil fuel.

El Paso Natural Gas Co. has ordered the first gas treating facility to use an advanced process recently developed by The Fluor Corp., Ltd. This process purifies natural gas laden with gross quantities of CO_2. Fluor will handle engineering, procurement of materials and construction of a 100-mmcf-per-day treating facility using this new process design. The $3-million plant will be erected in Terrell County, West Texas, after completion of engineering in July. Construction begins in May and is scheduled for completion in December.

The installation will be the heart of an expansion program El Paso is undertaking in the Brown-Bassett gas field. Although natural gas from this field contains up to 53 percent CO_2, the CO_2 can be removed "economically" by the new process. The Fluor Solvent CO_2 Removal Process uses an organic solvent to physically absorb high concentrations of CO_2 from natural gas. It can be applied to remove CO_2 from other types of gases, as well.

Air Products, Inc. has started production of liquid helium and liquid hydrogen at Allentown, Pa. The company is also installing an ultra-low-temperature plant at Iselin, N.J. The company, which has built and operates almost all of the

STRONG strainers in condensate line in new Cleveland skyscraper.

select the STRONG® strainer *designed for you!*

IN steam, air, gas, water, oil or chemical systems, a *correctly selected* strainer pays for itself many times. It protects expensive equipment (traps, control instruments, meters, etc.) and reduces over-all maintenance and service costs.

Assure your system maximum protection from dirt, scale, sludge and sediment . . . specify *the* STRONG strainer designed for your requirements.

Sizes: from ¼" to 8"

Service: 250 psi at 450° F to 2500 psi at 1100° F

Screens: stainless screens with .027", .045", .062", or .125" perforations (at no extra cost)

Types: "Y" or Angle with screwed or socket-weld (flanged) connections

Materials: semi-steel, ductile-iron, bronze, Monel, cast or block steel, or new all-stainless or Hasteloy

STRONG'S extensive line of rugged, high-quality strainers are available from your local STRONG distributor. Contact him for assistance in selecting the *right* strainer, or write for your copy of STRONG Bulletin SS—21C.

STRONG, CARLISLE & HAMMOND

508 Sandusky Street, Conneaut, Ohio

air traps • strainers • reducing valves • vacuum or pumping traps
continuous blowdown valves • separators • engine stops • F and T traps • safety headgear

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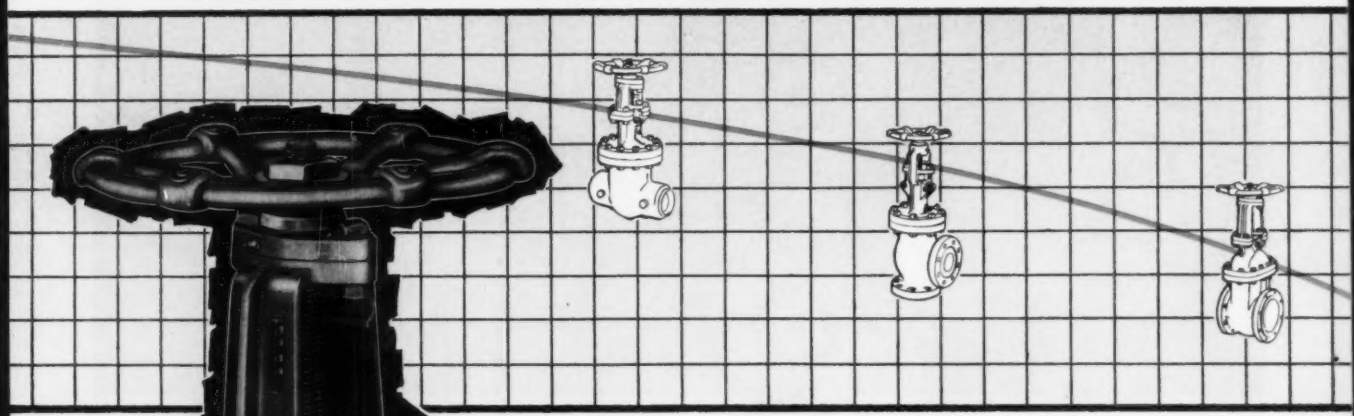
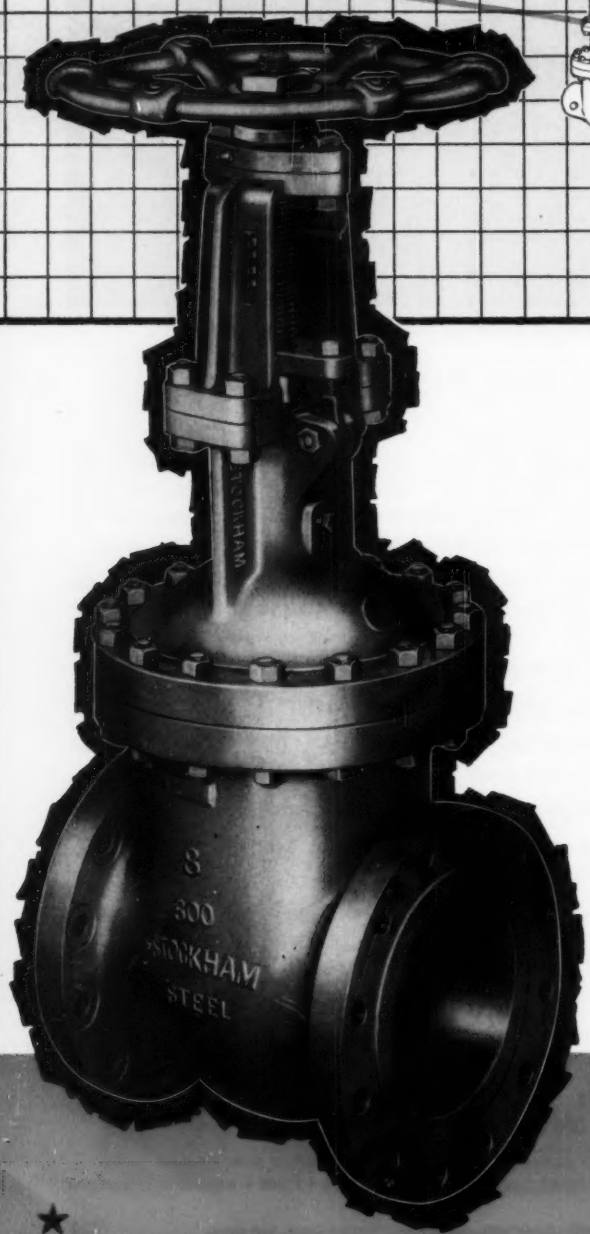
Engineered to Cut Valve Maintenance Costs

STOCKHAM STEEL GATE VALVES





GET THE design features you want and need to cut costs—get quality that lasts—in Stockham Steel Gate Valves.

Get full pipe size straight through port design. Seat rings are slotted; **no lugs protrude** in flow area.

These features make it the **easiest conventional type gate** valve to use in "pigging lines" and "hot tapping"—far more economical than conduit designs.

Other superior cost-cutting features include:

- ★ Disc and seat rings are precision ground for perfect seating
- ★ Disc guided throughout travel—eliminates wear
- ★ One piece yoke and cap—quick, easy maintenance
- ★ Non-corrosive copper nickel yoke bushing.

Precision quality control at every level of manufacture. Available in a wide variety of body and trim combinations. Gate, Globe, Angle and Swing Check Valves. 150, 300, and 600 Pound Pressure Classes.

CALL YOUR STOCKHAM DISTRIBUTOR OR WRITE

STOCKHAM
VALVES *and* FITTINGS

General Offices and Plant
4003 NORTH 10th AVENUE BIRMINGHAM 2, ALABAMA

★ NON-LUBRICATED PLUG VALVES...
CAST IRON, MALLEABLE AND DUCTILE IRON PIPE FITTINGS
BRONZE, CAST IRON, DUCTILE IRON, CAST AND FORGED STEEL VALVES

SOLD ONLY THROUGH DISTRIBUTORS

Building . . .

government's liquid hydrogen and liquid oxygen facilities, will soon complete its own plant for commercial distribution. The material will be produced and delivered by truck in specially designed vacuum-insulated containers throughout an area of a 600-mile radius. Shipments are also planned by air freight over a much larger area.

While the plant will produce both ultra-cold liquids (liquid helium at —452°F, about 8 degrees above absolute zero, and liquid hydrogen at —423°F), integrated design and construction permit increased production of one liquid when no production of the other is required. Aside from its conventional gas compressors, the plant features compact design and no moving parts in the liquefaction equipment.

Design and operation of the plant is largely based on experience the company has gained in several cryogenic breakthroughs. One of these is the large-tonnage liquid hydrogen facility built and operated for the Air Force near West Palm Beach, Fla. Previously produced on a laboratory scale only, tonnage production of this high-energy fuel is devoted to the missile program.

C.S.R.C. Dow Pty., Ltd. is planning an expansion of manufacturing facilities at Altona, near Melbourne, Australia. In addition to styrene monomer, for which a long-term contract is held with Australian Synthetic Rubber Co. and C.S.R. Chemicals Pty. Ltd., the Australian company will produce ethylene dichloride, caustic soda and chlorine. Ethylene dichloride will be supplied to B. F. Goodrich-C.S.R. Chemicals Pty. Ltd., a newly formed associate of The B. F. Goodrich Co., for use in the production of polyvinyl chloride resins. Caustic soda and chlorine will be available to Australian consumers of these basic industrial chemicals.

This expansion represents an additional investment of about $3.4 million in the Altona plant. C.S.R.C.-Dow is jointly owned by Dow and the Sydney based chemical company, C.S.R. Chemicals Pty. Ltd.

Sunray Mid-Continent Oil Co. plans to construct a $750,000 addition to its Criner gas products plant, McClain County, Okla. The Criner plant was placed into operation early in 1959 and was originally designed to process 5mmcf of gas a day. The new addition will increase gas capacity and handle the ultimate gas volume from the Criner field. After completion, the unit will process from 27-30 mmcf of gas a day. Work is currently underway and the unit should be in operation by early summer. Engineering work is being done by Tulomar Builders, Tulsa. Over-all project management is being handled by Sunray's engineering staff.

Delhi-Taylor Oil Corp.'s expansion and diversification in the petrochemical field gains momentum as construction

HAMER *Visible Shut-off*
LINE BLIND VALVES

HAMER PLUG VALVES

Will not stick or freeze. Perfect for hard-to-hold fluids. Simple plug adjustment nut eliminates sticking

Hamer Line Blinds are unsurpassed for positive action, easy operation, long-life service and lasting safety. One man can open or blind a line in less than one minute, and there is nothing like a solid plate for a PERMANENT LEAKPROOF SHUT-OFF. Bar or handwheel operation eliminates wedges, hammers, wrenches needed for spreading conventional flanges. Removes fire hazard of sparking and stops damage to equipment.

Write for FREE catalog

Hamer VALVES

MANUFACTURED AND SOLD BY
WELL EQUIPMENT MFG. CORP.
HOUSTON, TEXAS
Division of CHIKSAN COMPANY *a subsidiary of* FOOD MACHINERY AND CHEMICAL CORPORATION

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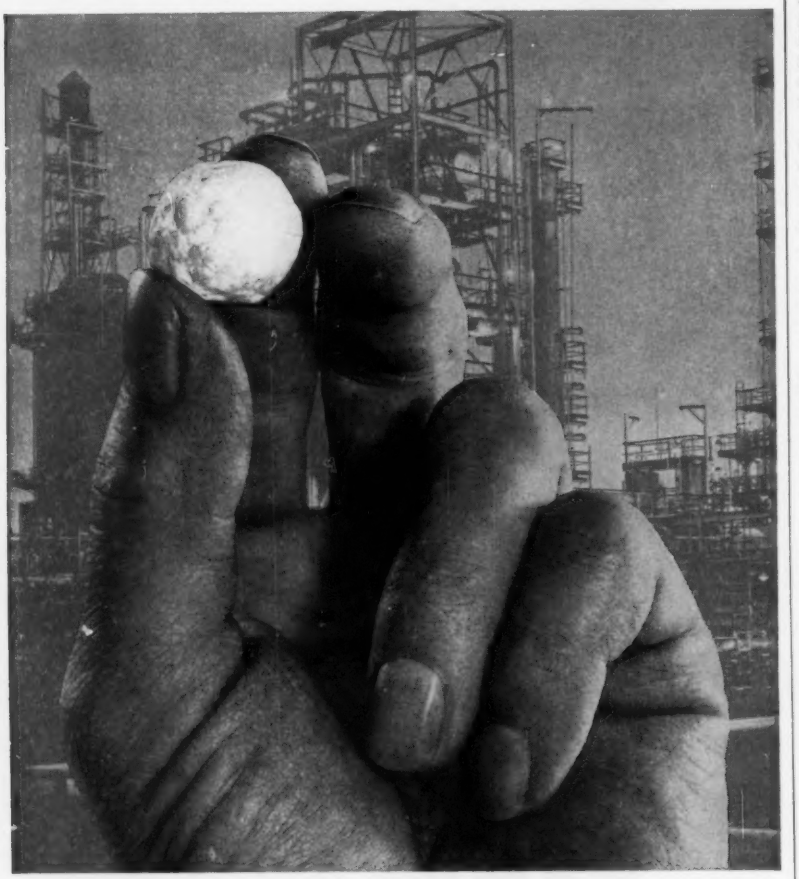
FOR CATALYST BED SUPPORT:

This Porter Mullite Pellet costs up to 50 per cent less!



Porter Mullite Pellets actually do cost up to 50 per cent less than most catalyst bed support materials now available. *And you make no operational sacrifice to gain this savings!*

Porter mullite pellets have been commercially tested for over three years, as inert support for active catalyst, in many major refineries. They've withstood all the trials of heat, shock and pressure without breaking or dusting. Porter mullite pellets have successfully resisted abrasion, erosion and crushing . . . completely protecting the valuable catalysts from contamination.

Convert to Porter mullite pellets now, and reflect these important cost-savings in your refining process. For complete information, write: *Refractories Division, H. K. Porter Company, Inc., Porter Building, Pittsburgh 19, Pennsylvania.*

REFRACTORIES PORTER DIVISION

H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION, PEERLESS ELECTRIC DIVISION; Specialty Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S. A.; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

Building . . .

begins on new facilities in Corpus Christi, Texas (announced in March issue, page 280). The new plant will produce orthoxylene, used in the production of phthalic anhydride for manufacture of polyester plastics and plasticizers for vinyl plastics, alkyd resins for paints and pigments for paints, plastics, textiles and floor coverings. The orthoxylene will be separated from a high-purity mixed-xylene stream currently extracted by a Platformer-Udex unit.

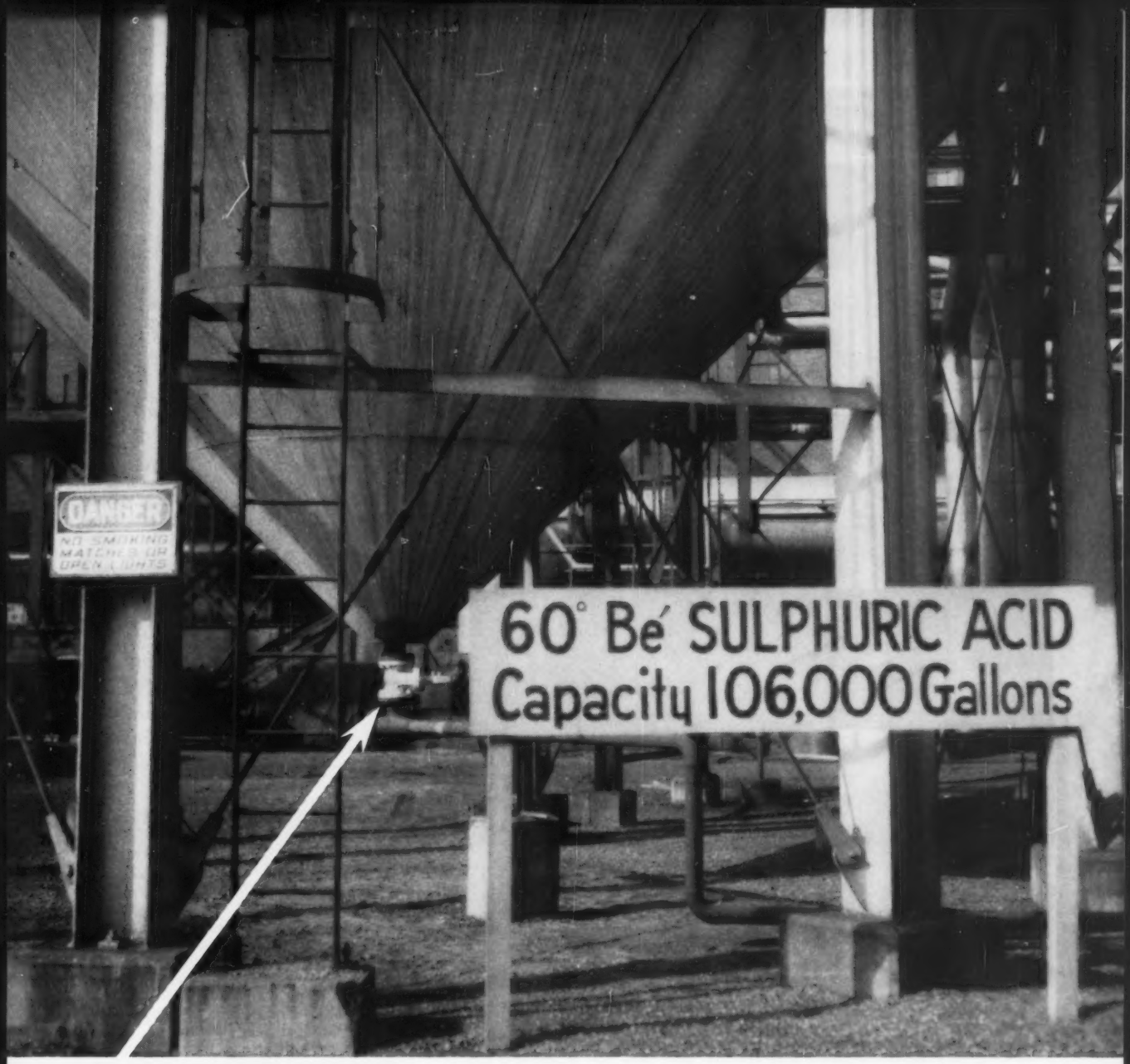
Total capacity of the new plant will be approximately 70 million pounds per year of high purity orthoxylene upon completion in June 1960. A novel feature of the new plant is that it is designed so that other chemicals will be derived from the company's diversified petroleum and petrochemical feed stocks. Thus, additional facilities available will allow Delhi-Taylor to add to its product diversification program.

British Hydrocarbon Chemicals, Ltd., jointly owned by The British Petroleum Co. and The Distillers Co., Ltd., plans to build three new major plants at its Grangemouth, Scotland, works. One of the plants will more than double existing capacity for butadiene, an important raw material for synthetic rubbers. The other two new plants are for the manufacture of methanol and ethylene dichloride. Methanol is used chiefly to make formaldehyde, mainly for the manufacture of synthetic resins. Ethylene dichloride is an important raw material for the plastics industry. It is planned to commission each of the new plants during 1961. The total investment in these three units is about $14 million.

Continental Oil Co. is planning a $2-million expansion program for its natural gasoline plant at Lake Charles, La., which will increase that plant's processing capacity from 100 to 150 mmcf of natural gas daily. Work on the project is expected to start in late June, with completion scheduled for January 1961. Contract for the construction has been let to Hudson Engineering Corp. In addition to boosting the plant's processing capacity 50 percent, the new unit will increase the Conoco facility's recovery of gas liquids, including ethane from the processed natural gas stream. Ethane will be purified and used in the manufacture of petrochemical products in the Lake Charles area. This is the second major expansion project at the unit in six years.

Nippon Mining Co., Ltd. has been licensed to construct a 6,000-bpd catalytic reforming unit and an 8,000-bpd hydrodesulfurization unit in Mizushima, Japan. Houdry Process Corp. will supply both units. The catalytic reformer will process 6,000 bpd of desulfurized petroleum naphtha, with the remaining 2,000 bpd from the desulfurizer used for jet fuel blending and specialty naphthas.

Mizushima, located in Okayama Prefecture between Kobe and Hiroshima, is



U. S. STEEL reports:

SMALL VALVE IN 4TH YEAR OF 'ROUND-THE-CLOCK' SERVICE!

It guards the outlet of one of the world's largest acid tanks for U.S. Steel. Here are the performance facts on this 4" Aloyco Gate Valve (made of Aloyco 20 Stainless Steel): It still shuts off tight. It has required no servicing except for minor packing adjustment. It has been on continuous 24-hour service for 4 years. People who pay for performance only, rely on Aloyco Stainless Steel Valves wherever corrosion is a problem. Want a safe, economical way to handle corrosives? Write: Alloy Steel Products Co., Inc., 1303 West Elizabeth Ave., Linden, New Jersey. 03

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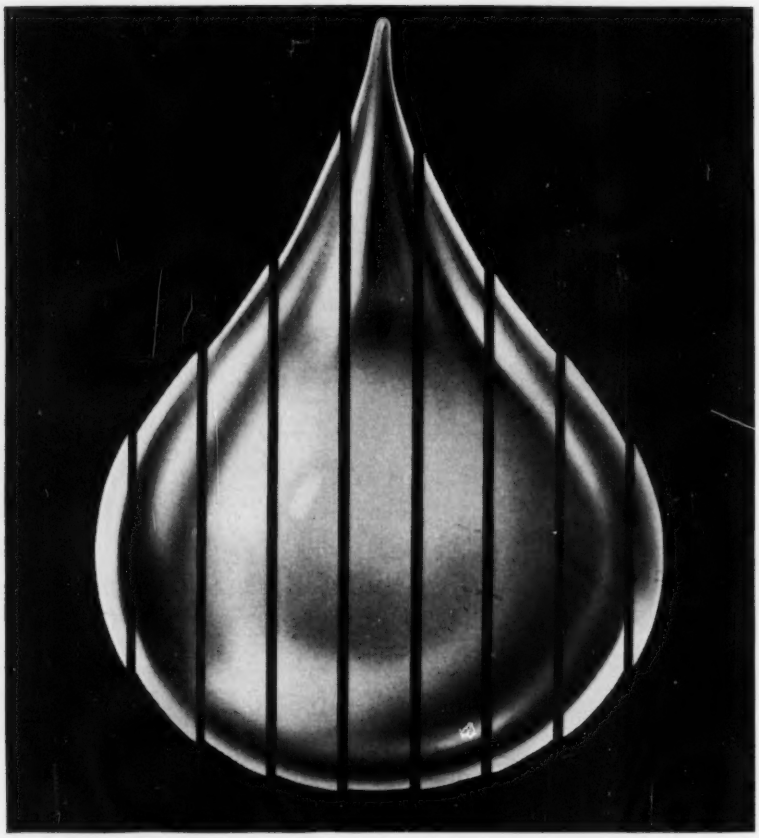
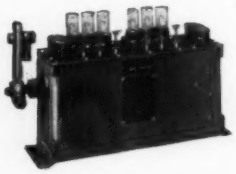
HOW THIN can you



slice a drop of oil?

Whether you want to deliver several drops or the minutest fraction of a drop per piston stroke, a Manzel lubricator will do the job exactly. Manzel lubricators force oil of any viscosity against the high steam, gas and air pressure so common in modern compressors, engines and machines. They start, stop, speed up or slow down in synchronization with your equipment. Write for our catalog explaining the whole line. Manzel, 256 Babcock Street, Buffalo 10, New York. For efficient lubrication



ask the man from

A UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

Building . . .

the newest Japanese petrochemical area. The new catalytic reformer at Nippon Mining will be the largest in Japan. Target date for completion of the two units is mid-1961. Houdry handled process design on the reformer and desulfurizer while the basic mechanical design was done by Catalytic Construction Co. Niigata Engineering Co., Ltd., Japan, in cooperation with Catlytic, will handle detailed design work and construction of the units.

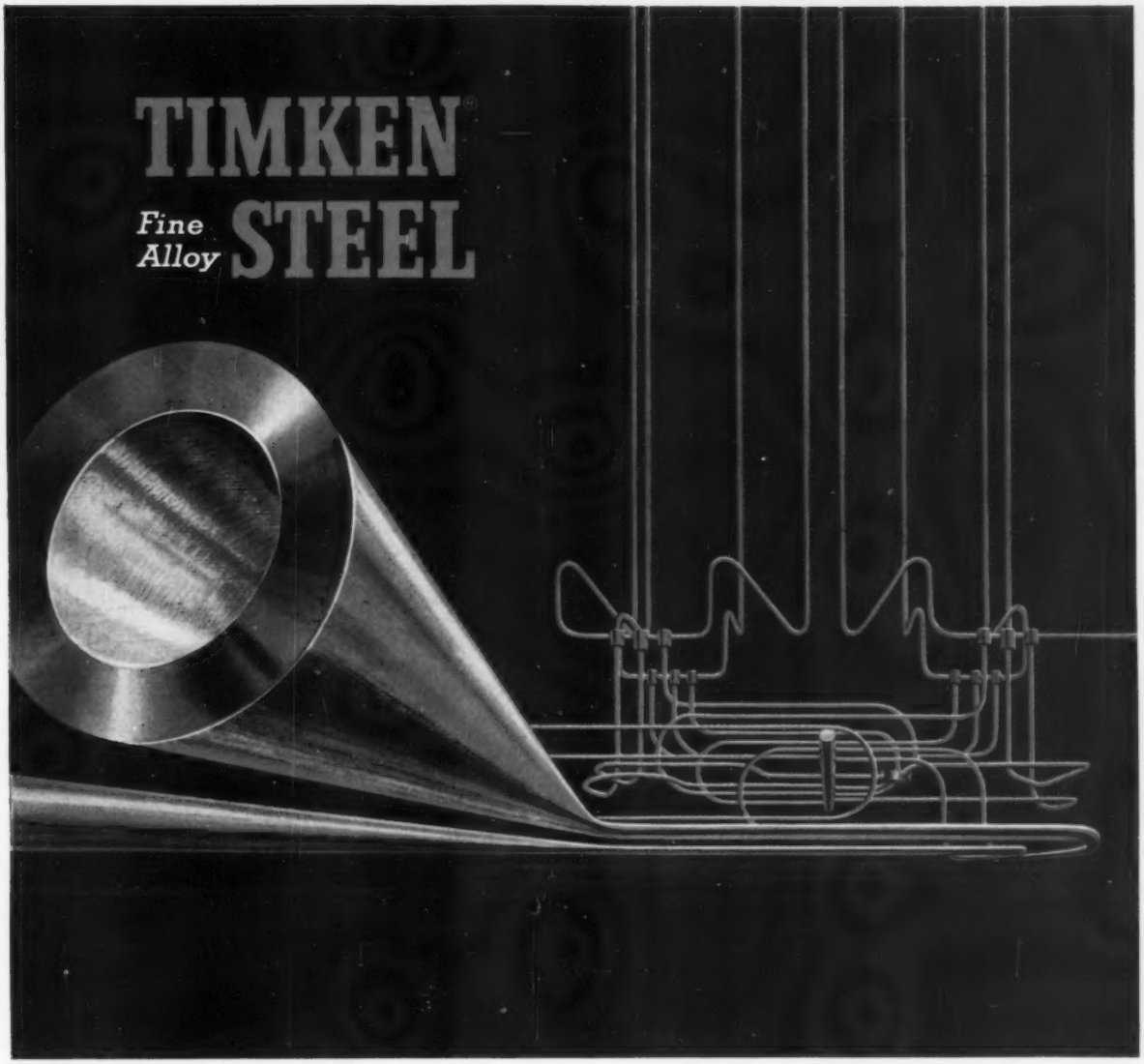
The Shell Refining Co. (Philippines) Inc. plans to construct a 25,000-bpd refinery in Batangas, Manila, in the Philippines. Construction will begin soon, with Filipino interests providing 25 percent of the total capital. The remaining money will involve foreign currency. Shell (Philippines), a joint British-Filipino venture, will provide foreign exchange needed for the refinery's construction, expected to take about two years. The deep-water refinery site will accommodate large tankers, and is accessible to main Philippine markets. The planned refinery would employ a Platformer to manufacture high-octane gasoline.

Continental Carbon Co. plans to build a $2.5-million carbon black plant at Bakersfield, Calif., the first plant of its type on the West Coast. The new facility will have an annual capacity of 30 million pounds of carbon black, which will be made from an oil feedstock. Construction is expected to start soon, with completion scheduled for mid-1961. Products of the new Bakerfield plant will be distributed to the West Coast carbon black market through Witco Chemical Co., distributor of Continental Carbon's products.

Ube Kosan Co., a big Japanese coal producer, plans to go into petrochemicals via a $22-million expansion program. The company will convert half of its fertilizer capacity to petrochemical feedstock. Ube Kosan would manufacture 21,000 tons per year of ethylene, 20,000 tons of polyethylene, and 5,000 tons of polypropylene. Negotiations for the construction contract are under way with Montecatini Co. and Scientific Design Co. Feedstock would come from Maruzen Oil Co.'s Matsuyama refinery.

Danubia Petrochemie A.G. has almost completed construction of Austria's first petrochemical plant at Schwechat, near Vienna. The plant, to produce 5,000 tons of polypropylene per year, is to be on stream by the end of this year. It will process refinery gases from the Austrian State refinery, under construction nearby. Until completion of the refinery, Danubia will polymerize propylene imported from Italy's Montecatini Co., a parent firm along with Austrian Nitrogen Works.

Bay Petroleum Co. plans to build a 2,000-bpd aromatics unit at its Chalmette, La., refinery. The unit will include facilities for the production of a full line



Watts cooking

Here's how they're cooking watts and keeping light bills down for customers of The Cleveland Electric Illuminating Company. In a new 250,000 Kw steam station at Avon Lake, Ohio, they put extreme pressures and temperatures to work to get more energy from each lump of coal. It's only the third power plant in the United States to crack the critical pressure barrier.

To transfer the red-hot 100 m.p.h. blast of steam from boiler to turbine with ordinary carbon steel would require piping of fantastic dimensions —with walls three feet thick—and from the top of the furnace down to the turbine it's a seven-story drop. The problem called for seamless tubing that was strong and tough—a super stainless steel.

The piping contractor for the new plant, The Pittsburgh Piping & Equipment Co. asked the Timken Company to produce AISI type 316 main steam piping for this extremely rugged high temperature, high pressure service.

Timken Company metallurgists specified a carefully balanced alloy content, made in the most modern electric melting furnaces. That's the key to producing pierceable super alloys. The result was stainless steel tubing with wall thickness light enough to permit a much lower cost. As for strength, the high alloy content of this steel should enable the tubing to carry red-hot steam 24 hours a day —for 40 years!

Whether your steel problem is size, weight, pressure, temperature, oxidation, or all of these things (as this problem was), call in Timken Company metallurgists! Their 40 years of experience in making fine alloy steel will give you a fast, low-cost solution. ***When you buy Timken steel you get . . .*** *1) Quality that's uniform from heat to heat, bar to bar, order to order; 2) Service from the experts in specialty steels; 3) Over 40 years experience in solving tough steel problems.* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.*

For more data on advertised products, use Readers' Service Cards, last page.

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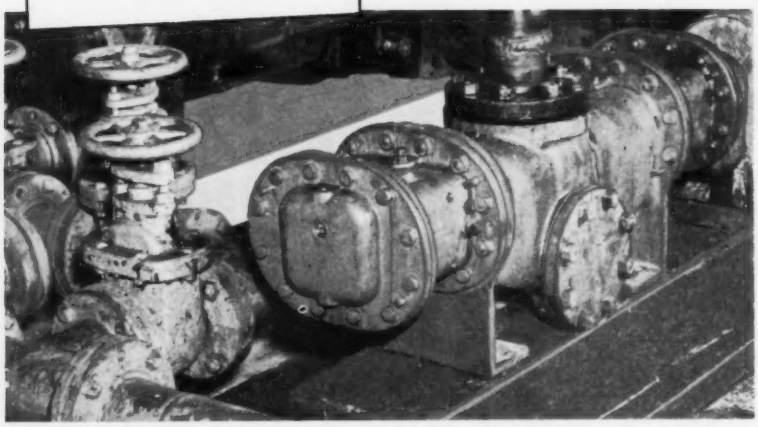
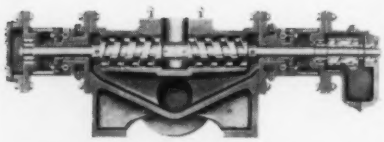
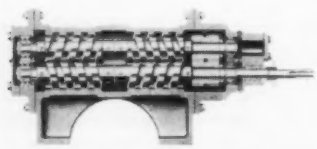


Sier-Bath SCREW PUMPS



External Gear and Bearing Bracket Type for non-lubricating liquids and semi-liquids



Internal Gear and Bearing Type for lubricating liquids and semi-liquids

Sier-Bath Screw Pumps maintain high volumetric efficiency because "Dual-Controlled" precision rotor design prevents rotor-to-rotor or rotor-to-casing contact—provides a continuous flow without pulsation, hammering or vibration . . . without strains, misalignment and wear on rotors, shafts, bearings and gears.

Result: Dependable, uninterrupted pumping service—less maintenance—easier servicing—longer pump life—lower overall pumping costs.

Capacities from 1 to 2,000 gpm.; viscosities from 32 SSU to 1,000,000 SSU.; discharge to 1,000 psi. for viscous liquids, 200 psi. for water and light oils. Horizontal or vertical construction. Corrosion resistant alloys, special bodies, stuffing boxes and bearings for special needs. See "Yellow Pages" for your Sier-Bath representative or write Sier-Bath Gear & Pump Co., Inc., 9261 Hudson Blvd., North Bergen, N. J.

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Founded 1905 — Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings — Member A. G. M. A.

Building . . .

of aromatic solvents. Installed will be an extraction plant and facilities for separation and distillation, and a catalytic reforming unit. Construction will begin this summer, with completion scheduled for spring 1961.

Tennessee Corp. will spend $13 million to build an ammonia plant at East Tampa, Fla., and to expand existing facilities. About $11 million will go into the plant, which will produce 100,000 tons per year. Due to be completed in early 1962, about 30,000 tons per year of the unit's output will go to Southern Nitrogen Co. The rest of the ammonia will be used by Tennessee Corp, for fertilizer. Capacity for this fertilizer is being doubled at East Tampa, at a cost $1.1 million. The company's Copperhill, Tenn., facilities for liquid sulfur dioxide will be doubled at a cost of $1 million.

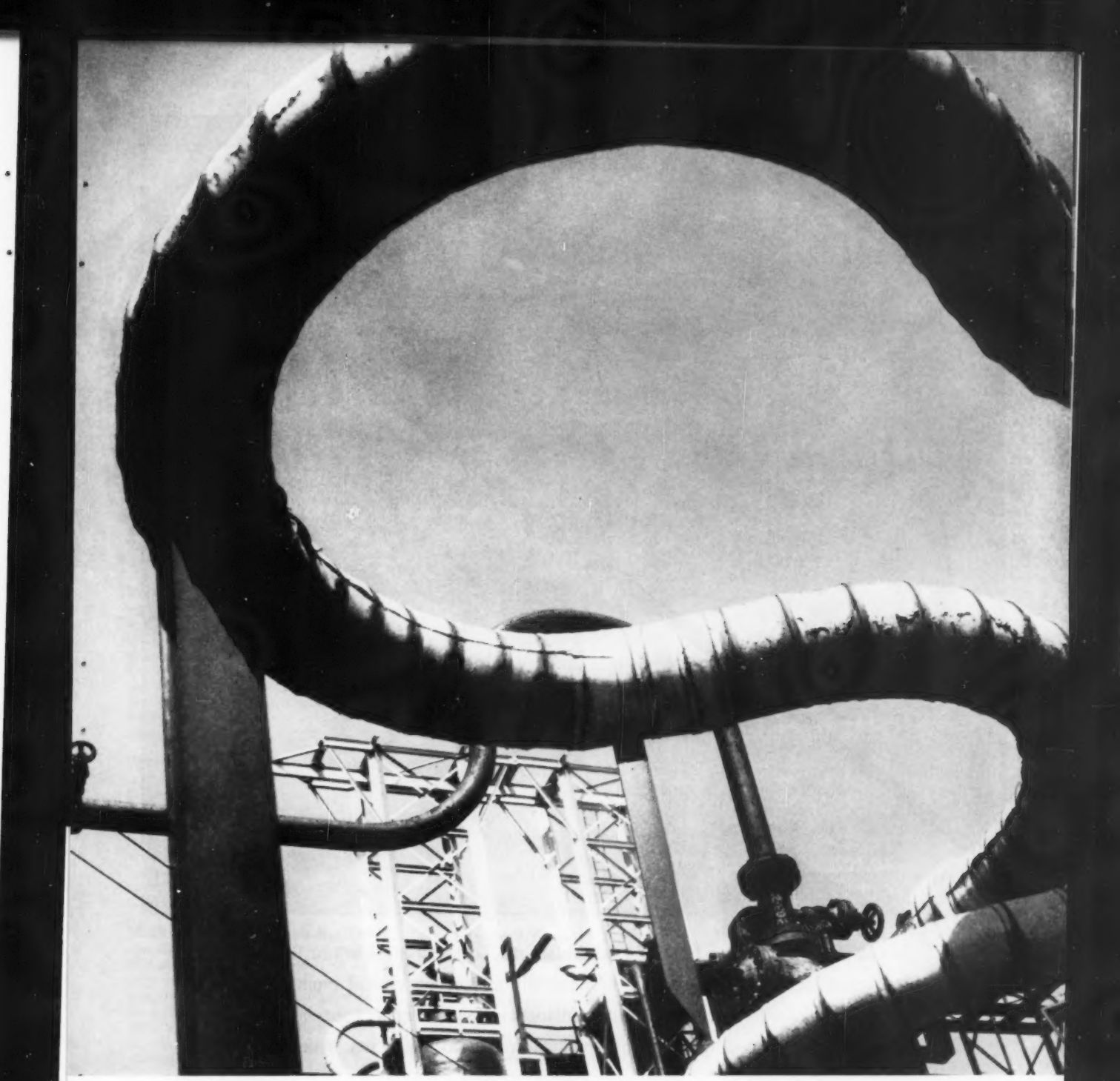
Copolymer Rubber & Chemical Co. is planning a $5-million expansion to increase its butadiene production facilities by about 50 percent at Baton Rouge, La. The firm will then have all the butadienes needed for production of synthetic rubber. Construction will begin in about three months and be completed in May 1961. Foster Wheeler Corp. will engineer and build the unit. The project is in addition to a $3-million construction program currently under way.

Monsanto Chemical Co. has placed expanded facilities for the manufacture of liquid sulfur dioxide at Monsanto, Ill., on stream. The plant incorporates the latest technological and engineering advances, and more than doubles manufacturing capacity for liquid sulfur dioxide at that point. Facilities are provided for loading bulk tank trucks, tank cars and one-ton containers.

Allied Chemical Corp.'s Nitrogen Division plans to expand capacity in two basic industrial chemicals, methanol and formaldehyde, at its South Point, Ohio, plant. The methanol will be used in formaldehyde production, and the latter in production of plastics and resins. Methanol capacity will be upped 50 percent and formaldehyde 35 percent.

Societe Industrielle Belge des Petroles (SIBP) plans to expand its current 4-million-ton-per-year capacity to 8-9 million tons. The firm, owned jointly by Petrofina and British Petroleum, plans to have the construction program completed by the end of 1962. The cost will be about $30 million, 90 percent of which will be spent in Belgium.

Imperial Chemical Industries, Ltd. and two Danish companies, Dampskibsselskabet AF 1912 A/S and A/S Dampskibsselskabet Svendborg, plan to build Scandinavia's first polyethylene plant. The Danish firms operate the Maersk refinery at Copenhagen, which will adjoin the new plant. To use the ICI high-pressure



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AN EXTRA 2000 TO 4000 BARRELS A DAY PER STILL

One eastern refinery increased the capacity of a pipe still from 16,000 barrels a day to between 18 and 20,000 – by modernizing the still in a program that included a Ljungstrom® Air Preheater.

The Ljungstrom boosts throughput like this by recovering waste heat from stack gas and putting it back to work in the combustion chamber. If you modernize to take full advantage of Ljungstrom's heat recovery efficiency, you also get much closer temperature control. At the refinery mentioned above, modern fuel-burning equipment – combined with Ljungstrom – increased product ratings an average of two octane numbers.

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For more complete details on what the Ljungstrom Air Preheater can do for you, or for a complete analysis of the heat recovery benefits, call or write The Air Preheater Corporation.

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PIPING FABRICATORS AND CONTRACTORS

Building . . .

process, the unit will be operated by a new subsidiary, Danbritkem A/S. ICI will have a 50-percent interest in the $11.2-million venture.

Golden Eagle Refining Co., a subsidiary of Panama Refining and Petrochemical Corp., plans to expand capacity of its Los Angeles refinery from 9,000 bpd to 30,000. Purchase of Panama Refining is currently being considered by Ultramar, a British-owned company. Ultramar would build a refinery on a Golden Eagle site and concession in Panama—provided the merger goes through.

Northwest Petro-Chemical Co. has completed construction of a $600,000 plant at Anacortes, Wash., to extract chemicals from spent caustic. Caustic liquor will come by road and pipe line from nearby British Columbia and Washington refineries. Most of the extracted acrylic acid, phenol and xylenol will be used in the local plywood industry, and some will be shipped to Japan.

Warren Petroleum Corp. is constructing a $2.5-million gas processing and sulfur plant in the Fashing field, Oklahoma. The unit was engineered and designed, and is being constructed by, Delta Engineering Corp. The gas processing unit will produce 75,000 gallons per day of butane, propane and gasoline, while the sulfur plant will turn out 50 tons per day of sulfur from acid gas.

Forth Chemicals Ltd. plans to expand its monomeric styrene plant capacity at Grangemouth from 30,000 to 50,000 tons per year. The product will be used in manufacturing polystyrene, synthetic rubber, paints and resins. Completion is slated for the end of this year. Forth Chemicals is owned by British Hydrocarbon Chemicals Co. and Monsanto Chemical Co.

Shell Oil Co. of Canada, Ltd., is considering purchase of a site southeast of Calgary, Alba., on which to build a refinery. To be constructed on a 310-acre site, the plant would manufacture domestic and automotive fuels. Capacity, says the company, would depend on marketing developments between now and the start of construction.

Arabian American Oil Co. has completed construction of a new gas-oil separating plant at Khursaniya. The unit was designed and built by Bechtel Corp. Arabian American also completed, in 1959, a gas injection plant at Ain Dar, and aviation manufacturing facilities at Ras Tanura.

Transcontinental Gas Pipe Line Corp.'s natural gas processing plant at Tilden, Texas, will begin recovery of sulfur from waste hydrogen sulfide. In operation since mid-1958. the sulfide-removal unit strips both hydrogen sulfide and carbon dioxide from 66 mmcf per day of natural gas,

Available in ¾" and 1¼" capacities . . . shown at right is Model 18-B-7 with ¾" rated capacity. Write for Bulletin 18-11.

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GARDNER-DENVER IMPACT WRENCHES hit harder . . . last longer . . .

Here are two new lightweight, easy-to-use impact wrenches that hit harder—yet don't wear themselves out. They're the result of intensive Gardner-Denver engineering to develop a powerful, long-lasting impact mechanism. The combination of a fast-accelerating air motor and a new, patented clutch mechanism assures positive starts, efficient impacting and lowest maintenance.

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Model 18-B-9 impact wrench with 1¼" rated capacity. Write for Bulletin 18-15.

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Building . . .

and burns the off-gas in flares. Sulfur recovery will be in the hands of Trans-Jeff Chemical Corp., a newly formed subsidiary of Transco and Jefferson Lake Sulfur Co.

Toa Nenryo Kogyo Co., Japanese subsidiary of Standard Vacuum Oil Co., is seeking government approval for setting up a new petrochemical subsidiary at Kawasaki, Japan. The new company plans to produce 10,000 tons per year each of polypropylene and octanol derivatives.

Shell Chemical Co.'s Torrance, Calif., alkylation plant has added a new isoamylene unit. The chemical will be used in production of Shell's polyisoprene synthetic rubber, which has a composition and properties similar to those of natural rubber.

Fabrika Azotnih Dubriva, Yugoslavia plans to build a high-pressure desulfurization unit to handle 2,500 pound moles per hour of synthesis gas. West Germany's Pintsch Bamag A.G. will build the plant. Completion of the unit, which will use the Alkazid process, is slated for this year.

Showa Denko, K.K., Japan, is building a carbon black plant at an undisclosed site, to produce oil furnace black for the rubber industry. The new plant will employ a Phillips Petroleum Co. process.

Standard Vacuum Oil Co.'s new Philippine refinery is almost complete. The plant will feature an air cooling system to provide 70-90 percent of the plant's cooling requirements, single-control-point instrumentation, and deep-water loading facilities. The refinery is being built on Bataan.

Koyo Manka Kaisha Co. plans to team with Maruzen Oil Co. to build a 20,000-bpd refinery in Singapore. The Japanese firms announced their plans through Shell Oil Co.

Continental Carbon Co. has completed construction of its carbon black plant at Westlake, La. The new unit boosts Continental's Westlake capacity by about 25 million pounds to 70 million pounds per year of furnace black.

Carbide Chemicals Co. plans to double capacity for ethylene oxide and derivatives at its Montreal East plant. The project is to be completed by the first quarter of 1961. An expansion begun earlier will up polyethylene capacity to 65 million pounds per year.

Godfrey L. Cabot, Inc. is adding 110 million pounds per year of oil-furnace-black capacity to four of its Southwestern carbon black plants.

B. F. Goodrich Co. reports that it has 11 new plants or plant expansions under construction, and which will begin producing income at moderate levels this

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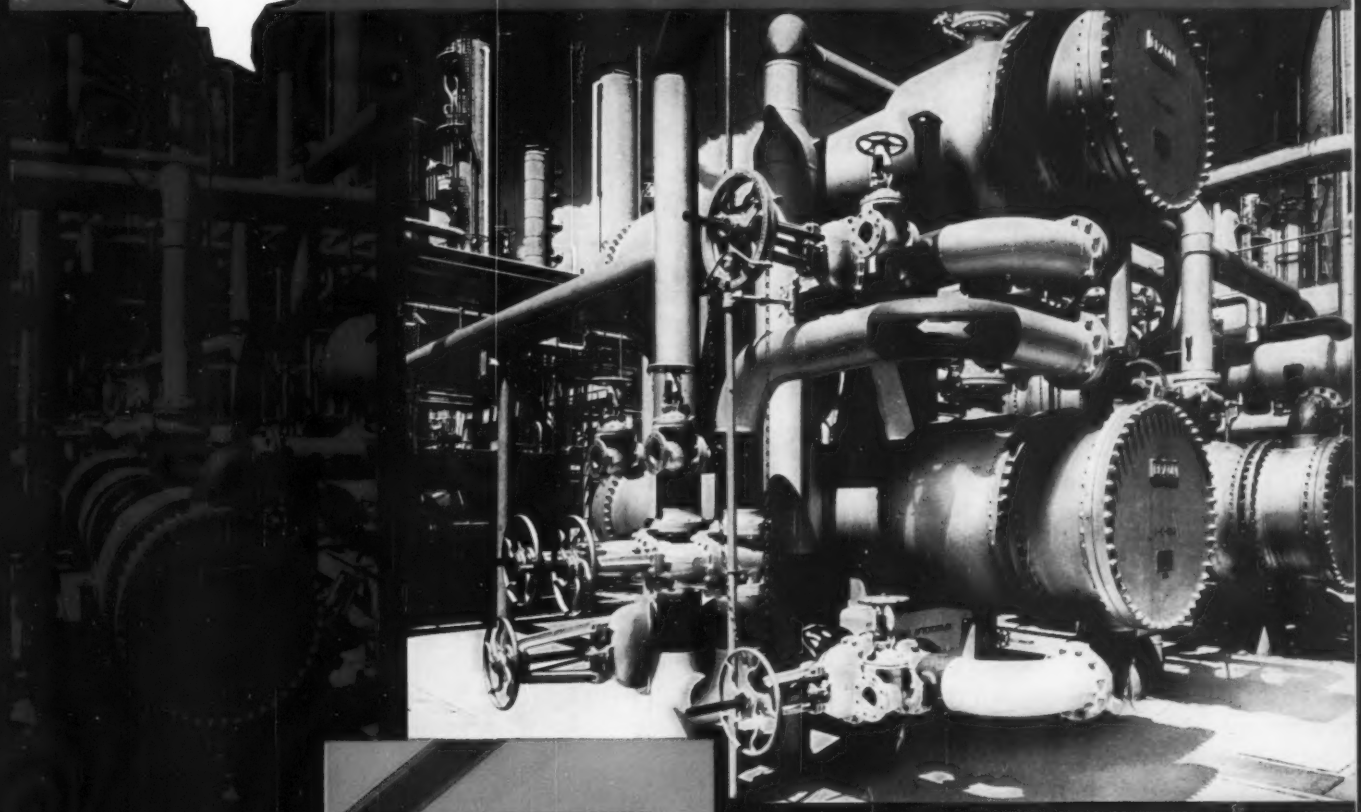

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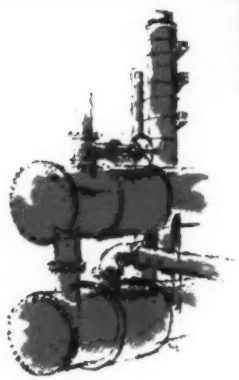

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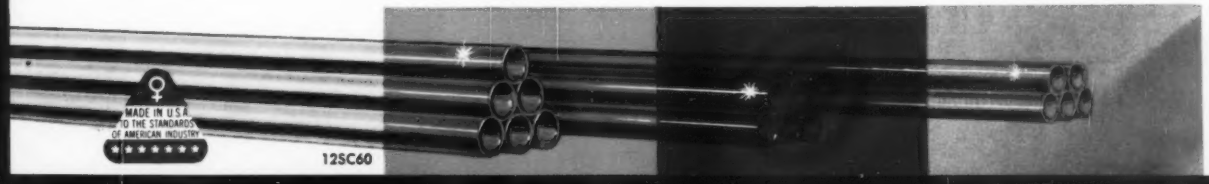

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HIGH GASOLINE TAXES

all oilmen should know!"

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A. About *one dollar!*

Q. At what rate, then, is gasoline taxed?

A. At about 50% of the price, or nearly five times the tax rate on such luxuries as furs and diamonds.

Q. How much have gasoline taxes increased in the last ten years?

A. About *51%*.

Q. What about gasoline prices in this same period?

A. They have increased only 5%, as compared with 22% for prices in general.

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Building . . .

year. Another six should become profitable in 1961 and four more in 1962-64, says the company.

Tunisia reports that the Bourghiba government is considering construction of a refinery to process crude oil from the recently completed Edjele-Skira pipe line. The Italian company, Ente Nazionale Idrocarburi, has proposed a 1-million-ton-per-year plant at Skira.

Societe Vinylacq, a new subsidiary of Pechiney, Saint-Gobain, and a French bank, plans to add a vinyl chloride plant to France's Lacq-gas-field chemical complex. Already produced in the area are ammonia, acetylene, nitric fertilizers and acid, butanol and methanol.

Oronite Chemical Co. plans to team with British Petroleum Co. for construction of plants in West Germany and Great Britain. Both would produce p-xylene, o-xylene, benzene and ethyl benzene. Construction would begin by the end of this year.

Greece will add a plant capable of producing 25,000 tons per year of LPG to its 1.4-million-ton-per-year refinery at Aspropyrgos, near Athens. This plant has been leased by the Greek government to a local firm under the control of shipowner S. Niarchos.

Czechoslovakia is planning to build "Slovnaft works" unit in Bratislava to produce a complete line of petrochemical and oil products, including plastics and synthetic fibers. Crude oil will be supplied via the new Russia-East Europe pipe line.

ABCD, a subsidiary of the Bombrini-Parodi-Delfino Cementi Segni group, Italy, plans to produce polyethylene resin at its Regusa refinery. Initial manufacture of this product would be about 13,000 metric tons per year.

Phillips Petroleum Co. is studying a plan to make metallurgical coke from heavy crude oil in Venezuela, but no definite decision has yet been made. The project would involve six Monagas State wells in which Phillips has a controlling interest. These wells produce 9 and 14-gravity crude oil.

The Standard Oil Co. (Ohio) has started up its new asphalt producing center at Lima, Ohio. This $300,000 facility will have an annual capacity of 5-10 million gallons. From other Sohio refineries, certain grades of asphalt will be brought into the new plant where other asphalt products will be produced.

Raffineries Du Rhone, Switzerland, of which Ente Nazionale Idrocarburi, Italy, owns one third, plan to build and operate a refinery at Aigle, Switzerland. The 2-million-ton-per-year plant will be fed from a pipe line from Genoa.

Royal Dutch Shell is planning a $21.8-million expansion of its Dock Sud refinery in Argentina. The expansion will include an 800-ton-per-day catalytic reformer, and storage capacity for 945,000 barrels.

Dutch State Mines, The Netherlands, plans to triple polyethylene capacity. The company is reportedly negotiating a contract with Esso Standard Oil Co. to supply light naphtha for feedstock.

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They don't cost,
they pay.

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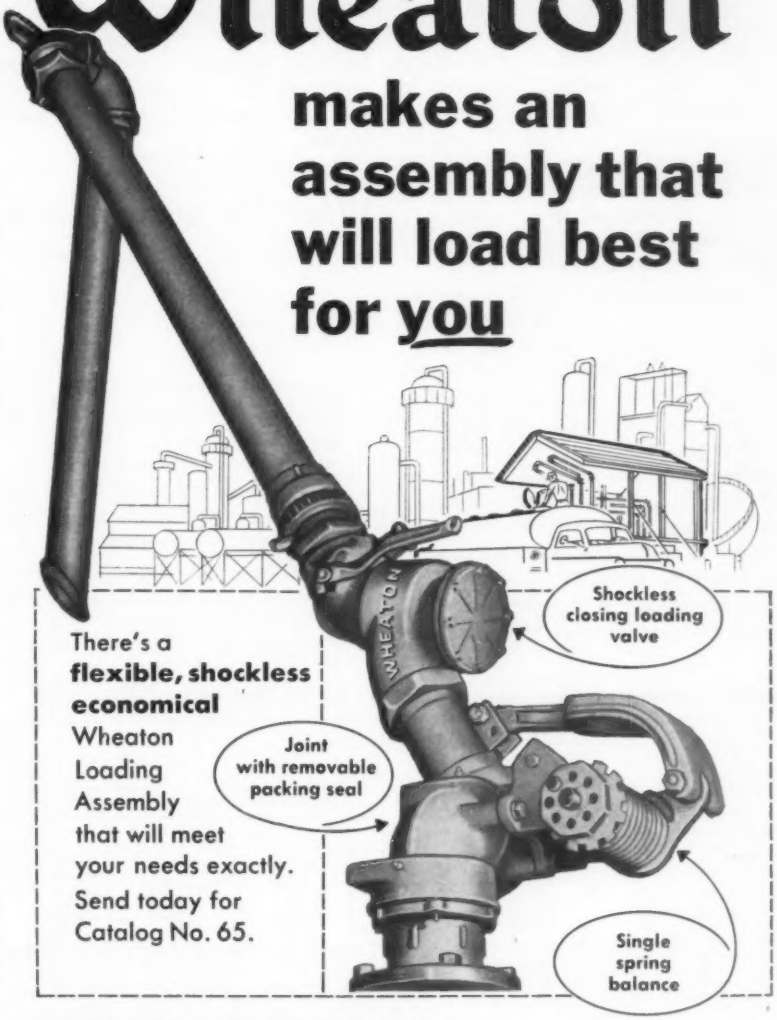
makes an assembly that will load best for you



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For more data on advertised products, use Readers' Service Cards, last page.

What's Happening...

NGAA Survey Reveals Extent of Automation

ALTHOUGH "AUTOMATION" can take on many meanings, in the natural gasoline industry it usually is regarded to mean the application of automatic control. Thus the principles of automation have been in use here for about 20 to 30 years before the word came into being.

Recently, the Natural Gasoline Association of America surveyed its membership to determine just how far automation has come. The results show the majority of the natural gasoline companies are actively engaged in automation of some sort. Unattended or partially unattended plants are now in use.

Partial results of the NGAA survey are shown in table at right. More than 200 gasoline plants are represented in this tabulation. Although there are no completely unattended plants reported, a few do approach this status. The use of automation to make the small plant economically feasible is indicated by the approximately two-thirds of the partially unattended plants that have a capacity of under 20 MMcfd.

This tabulation represents reports from 34 companies. The column marked "Number of Companies Reporting" shows the different companies operating the plants and equipment in the tabulation.

Only five gasoline plants were reported as having remote contact with employes not directly on the plant site. This is a large percentage of the partially unattended gasoline plants reported. This could indicate the need for surveillance of the unattended plants.

Of the 34 companies reporting, 21 reported plants having capacities of under 20 MMcfd. Some of these companies also have plants with capacities of more than 20 MMcfd, so that 27 companies were reported in this category of bigger plants. The extent to which instrumentation is used in the plant having 20 MMcfd and over is shown in the table below.

Of the plants shown, the typical plant is an unrefrigerated absorption plant using conventional pneumatic control systems. Over-all, the use of chromatography predominates with five of them being used on automatic control.

The NGAA survey also includes information on the extent of instrumentation of compressor stations and computer usage.

Condensed from a presentation by John L. Ryan before the NGAA, Galveston, Texas, April 1960.

What the survey shows . . .

How many gasoline plants do you operate.....	Time Interval (Hr/D)	PLANT CAPACITY: Under 20 MMcfd	PLANT CAPACITY: 20 MMcfd and Above	Number of Companies Reporting
Without a plant operator present?.....	24	2	1	11
	22	3	2	
	16	5	1	
	8	3	0	
Without other plant employes present?.....	24	4	4	12
	23	0	1	
	16	5	4	
	8	2	1	
Without any plant employes present?.....	24	0	0	7
	23	0	1	
	16	4	0	
	8	5	0	
Without any plant employes present, but having remote contact with an employe?.....	24	2	0	4
	16	2	1	
	8	0	0	

Plants having gas handling capacities of 20 MMcfd and over . . .

	CONTROL EQUIPMENT: Manual	Miniature: Pneu.	Miniature: Elect.	Conventional, Pneu.	Conventional, Elect.	Proc. Analyzer	On Stream Analyzer	COMPOSITION ANALYZERS: LTD	Mass Spec.	Infra-Red	Chromatograph	Gravitometer	Calorimeter	Moisture Monitor	H_2S Analyzer	IBP & EP	Number of Companies Reporting
Liquid Extraction																	
Absorption	..	9	..	111	..	..	3	2	..	..	6	..	..	..	..	..	26
Adsorption	..	..	2	7	..	..	..	..	..	..	..	..	..	..	..	..	6
Refrigeration	..	3	..	22	..	..	2	1	..	..	4	..	..	..	..	..	17
Fractionation																	
Deethanizer	..	8	..	82	..	2[1]	2	19	..	..	11	..	..	..	..	2	23
Depropanizer	..	10	..	67	..	1[1]	4	10	..	1	20	..	..	..	..	2	26
Deisobutanizer	..	6	..	17	..	1[1]	8	2	..	1	9	..	..	..	..	..	16
Debutanizer	2	3	15	50	..	2[2]	4	23	1	1	18	..	..	..	..	2	26
Gas Treating																	
Dry desiccant	50	..	..	22	1	..	45	..	..	..	3	20	19	3	..	..	22
Glycol	2	..	..	2	..	..	..	..	..	..	..	..	..	..	12	..	
Sulfur removal	66	..	..	1	..	..	12	..	..	..	..	..	..	..	..	..	
Product Handling																	
Sulfur removal	42	..	..	9	..	..	..	..	..	..	..	..	..	..	..	..	14
Dehydration	41	..	..	8	..	..	..	..	..	..	..	..	..	..	..	..	20
Product storage	99	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	26
Product shipping	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	27

[1] Uses chromatograph for control.
[2] Includes one chromatograph and one IBP-EP recorder.

QUALITY
(whatever the grade)

QUANTITY
(whatever the volume)

SERVICE
(when, where and the way you want it)

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DEPENDABLE DELIVERIES OF NATURAL GASOLINE

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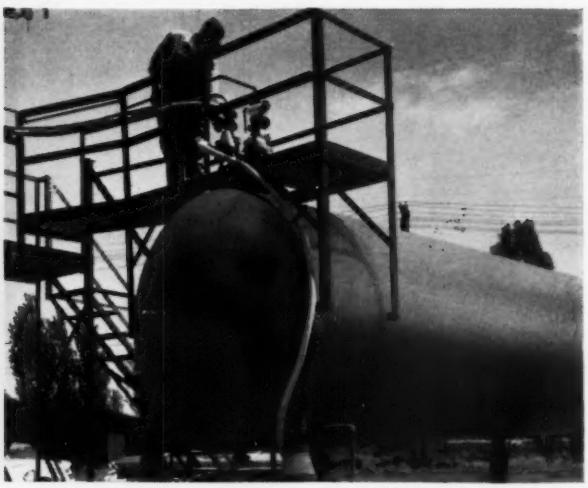
FLUIDICS* AT WORK

Storing a sticky fluid? . . . an ultra-pure one?



. . . a harsh corrosive?

Glasteel thrives on solving problems like these

"Problem Storage" is a primary area for the Glasteel storage tank.

If your product is sticky, Glasteel helps you overcome the cleaning problem. Because it's glass inside (steel outside), your Glasteel tank meets the product with a smooth, glossy surface unmatched by even the most highly finished metal or plastic. Your product has little chance to adhere or build up residue in a Glasteel tank.

If it is sensitively pure, your product will pick up no impurities from a Glasteel tank. Glass is inert. Never puts itself into the product. It protects the purity, flavor and aroma of whatever you store in it. That's why it should be no surprise to learn that Glasteel storage is a standard practice in the pharmaceutical industry.

If it's a corrosive, you can store your product safely in Glasteel. Glasteel is completely resistant to all acids (except hydrofluoric) and to alkalies at ambient temperatures.

Save two ways. The profit return with Glasteel storage tanks is reflected in two ways:

#1. In tanks of 10,000 gallons and more, Glasteel is actually lower in price than stainless steel. In the 30,000 gallon range they cost half as much. These savings are immediate.

#2. In tanks of *any* size you save money when storing corrosives, because Glasteel tanks last 20 years and more, require little maintenance.

More information. Our Bulletin 975 spells out the economic facts and specifications for Glasteel storage. We'd be happy to send you a copy, or to answer specific questions. Write to the address shown on the facing page.

For more data on advertised products, use Readers' Service Cards, last page.

What's new in reactors?

The silhouette of this reactor is different from our earlier "R" series. So is the exterior color—a light blue. In fact from top to bottom this Pfaudler® "RA" Series Reactor is new.

Two new drives. Select the TW for power requirements up to 15 H.P., or the BH if your needs take you up to 60 H.P. and higher. Both are compact, easily installed and maintained. Both are very quiet, too, a much-appreciated difference when a full line is in operation.

Mirror-image top head. The symmetrical pattern formed by an equal number of nozzles on each half of the top head means you need only a minimum of headroom and pipe to hook up an "RA" reactor. You can also feed two side-by-side reactors from a single tee.

Offset drain. You get fast drainage because the outlet is offset and in the direct sweep path of the agitator. The outlet is in line with the top-head manhole for convenient inspection.

Corrosion resistance. Inside there's Glasteel 59 for resistance to all acids (except HF) to 350° F., and even 450° F., depending on concentration. Mild alkalies at moderate temperatures are also permissible. Thermal shock resistance is 30% greater than in the "R" Series. Abrasion resistance has been increased by 20%.

And the smooth surface that resists build-up gives you high heat transfer, increased product yield, fewer shutdowns for cleaning.

Stock delivery. Two weeks from receipt of your order you can have delivery on 500, 750, 1000 and 2000 gallon vessels. We need a little more time for other standard sizes through 4000 gallons.

New Bulletin 988 puts all the details at your finger tips. Write for it.

How to match the material to the application

This solvent recovery condenser has 733 square feet of heat transfer surface. It took 140 one-inch-diameter Monel tubes, 20 feet long, to provide this. The shell and expansion diaphragms are also made of Monel. Bonnets are carbon steel. This unit will be used at 75 psi, at 400° F. For a more corrosive service, a duplicate design is being made of Carpenter—20 Cb.

All of which leads us to the point that you get the right materials that best suit your application when you come to Pfaudler.

We are in the unique position of offering a complete choice—in solid or lined construction. We can pick from (in *combination* where needed) Glasteel, Monel, Hastelloy, nickel, aluminum, stainless, Inconel, tantalum, titanium, zirconium, etc.

Outline your problem and you will receive a prompt, thorough recommendation.

Put F-C Glasteel Pipe† to work with just four easy steps

Here's a corrosion-resistant, high-integrity, lined pipe that you can install in four easy steps.

First take a section of Pfaudler F-C Glasteel Pipe (the F-C means "field cut") and cut to the length you want on a standard, dry abrasive cutoff wheel.

Next, thread—just as you see in the picture.

Third step: Fire-polish using a small, portable furnace. (You can get one from Pfaudler at a modest cost that you will *recover* through the savings from a few installations.)

Then, thread on flange and belt sand to assure that gasket seat is flat and the flange connection seal-tight.

Details: This pipe is ⅛ inch glass inside, steel outside. It resists most acids to 350° F. and handles alkalies at moderate temperatures. It's pressure rated at 150 psi and you can currently get fast delivery on 1½, 2, and 3-inch diameters in lengths through 10 feet. Ask for Bulletin 989.

Address all inquiries to our Pfaudler Division, Dept PR-50, Rochester 3, N. Y.

FLUIDICS AROUND THE WORLD

Pfaudler Permutit is a world-wide company with manufacturing plants in Germany, Great Britain, Canada, Mexico, and Japan, as well as the United States.

†Patent applied for

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Specialists in FLUIDICS . . . the science of fluid processes

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

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For Steam Tracing
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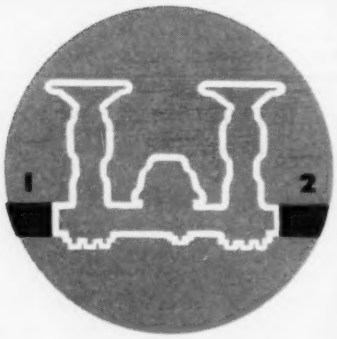
FORGED STEEL STELLITED SEATS

NO EXTRAS
The only complete Steam Trapping Hook-up with
JUST 2 CONNECTIONS



ONLY 30 SECONDS
to replace the entire steam trap

SAVE:

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$60.00 in cost	50%
14 fittings	
19 welded and/or screwed joints.	

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Happenings . . .

WPRA Computer Meeting Slated for Houston in May

The next WPRA-sponsored computer conference is scheduled for May 24-25, 1960 at the Ben Milam Hotel, Houston. It is designed to assist computer specialists who are working on problems of petroleum refining. Formal papers and workshop groups are scheduled during the two day session. Lee R. Dukes, Kerr-McGee Oil Industries, Inc., Oklahoma City, a member of the Planning Committee, will be conference chairman.

Workshop leaders will cover the two subjects to be studied. Gasoline blending by computer techniques and cat cracker simulation by linear programming and model building will be the topics having greatest emphasis at the meeting.

NewGovernment-Controlled Refining Firm for France

A new French government-controlled refining company, Union Generale Petroliere (UGP), has been established. All government-controlled producing companies operating in metropolitan France, Africa and the Sahara, will participate as follows: SN-Repal, 33⅓ percent; Regie Autonome des Petroles, 33⅓ percent; and SNPA, CEP, and PREPA, 33⅓ percent. Assets of the new firm will include a majority interest in California Texas Oil Co.'s refining, marketing and marine facilities in France. It will also take over distribution facilities of the French independent distributor Cie. Francaise des Produits Petroliferes.

NPA-WPRA Merger Is Reported 'In the Mill'

The National Petroleum Association is considering a merger with the Western Petroleum Refiners Association, according to an announcement made at the April Mid-Year Meeting of NPA. While acknowledging the question of such a move to be a "grave" one, Charles E. Spahr, president of The Standard Oil Co. (Ohio) said there were reasons to believe the "merger would not lead to a loss of either organization but rather to a combination preserving and enhancing the values of each."

'Positive Approach' Is Recommended for Oil

The oil industry should take "a positive and cooperative approach rather than one of defeat and belligerance" in such matters as antitrust, imports restrictions, gasoline taxes and "so-called politically inspired" legislative proposals, according to Charles E. Spahr, president of The Standard Oil Co. (Ohio). Speaking at

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HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin G-1.

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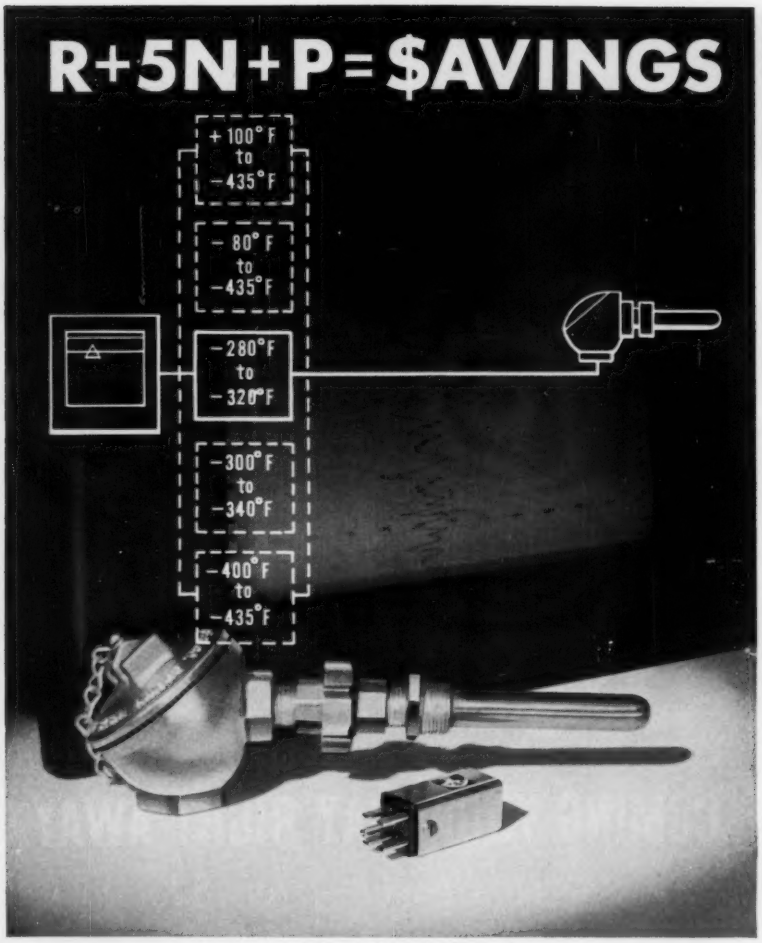

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Standard Networks are available to adapt any probe to the temperature spans indicated above.

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Happenings . . .

the midyear NPA meeting, he cited the exoneration of 29 companies of price conspiracy charges. Spahr declared, "I do not believe the industry should indulge in any 'I told you so' campaign. I feel it is better that we encourage the government to treat future cases with the dignity that they deserve. The prosecution should be made to realize that unfounded charges will undermine the very cause it professes to protect." Spahr viewed the imports program as "as equitable as can be devised." He questioned the wisdom of the 90-percent federal contribution to the highway program, adding that it may result in "designing new highways beyond requirements."

OCAW Maps Future Policy At Meeting in Dallas

In a two-day policy meeting in Dallas during April, representatives of 45 OCAW locals in Texas, New Mexico and Louisiana recommended the following:

- A substanial general wage increase with consideration given to application, in part, to fringe benefits.
- Companies should pay all fringe benefit costs, or, alternatively, payment should be made from trust funds jointly administered by management and locals.
- A shorter work week should be sought through reduction of overtime with a stand-by work week clause in line with the World-War-II policy.
- Contract labor for maintenance forces should be eliminated.

The national OCAW Bargaining Policy Committee will study the recommendations. The committee will meet in two or three months, according to union president O. A. Knight.

Bureau of Mines Reports On January Crude Picture

Total crude oil capacity of refineries in the United States during January as reported by operating companies was 9.65 million bpd, indicating an operating ratio of 85.8 percent, compared with 86.1 percent in December, according to the Bureau of Mines. U.S. production of crude oil in January averaged 7.23 million bpd, up 37,000 bpd from December 1959. Total crude demand for January increased 129,000 bpd—an increase of 227,000 bpd for domestic and a decrease of 98,000 bpd for foreign. Crude runs to stills in January averaged 8.3 million bpd compared with 8.1 million bpd in December. Demand for all oils in the 50 states during January was 10.7 million bpd, including exports of 194,000 bpd and domestic demand of 10.5 million bpd.

Dow to Give Leaves of Absence to Ph.D. Seekers

A fellowship program which will enable employes to take a leave of absence

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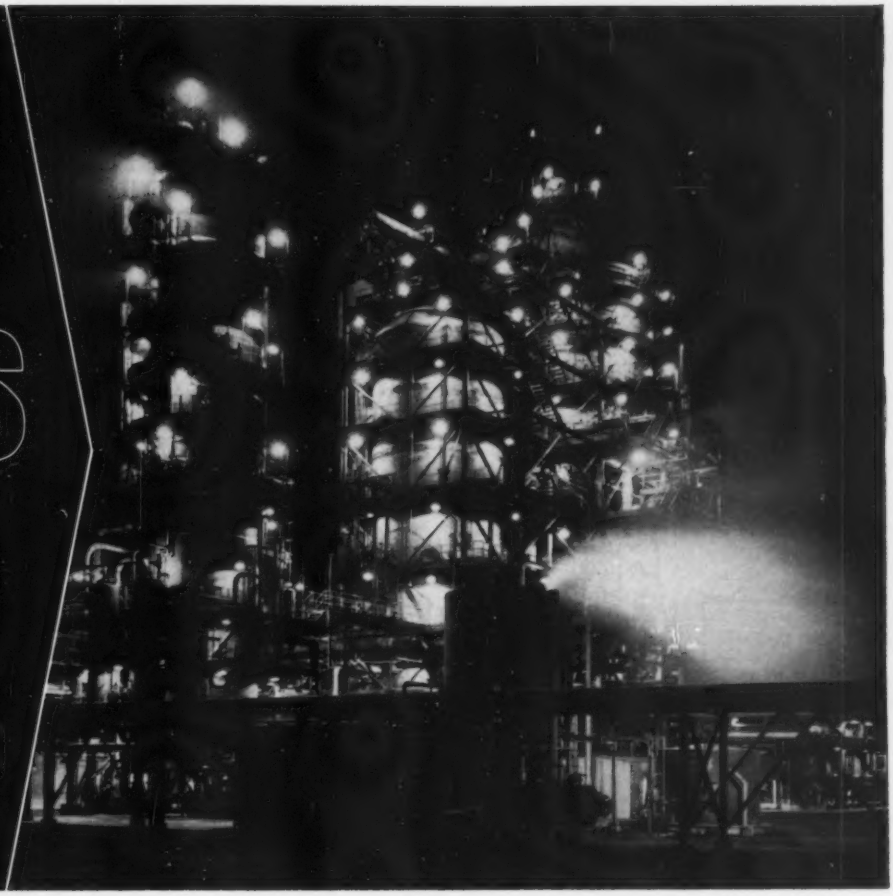
HOW TO PUT A PLUS FACTOR IN YOUR COATING PROGRAM



Every good Maintenance Supervisor looks for something extra — a plus factor — when he chooses the coatings for his program. You'll find it in Napko Industrial Coatings, high quality, durable coatings with the longest life span possible, *plus* responsible follow through.

During and after most applications of Napko coatings, you'll find a highly trained, well qualified Napko Sales Engineer carefully inspecting the coating to make sure you get what you pay for, whether it's at the top of a stack or inside a storage tank; this is responsible follow through, the crucial ingredient that doesn't come in the can. There's no substitute for it.

If you have a corrosion problem — unique or commonplace — there's a Napko Industrial Coating to do the job and a Napko representative ready to help you solve your problems and make sure you get the most for your money. Help yourself by contacting your Napko industrial division.

Write or call today.

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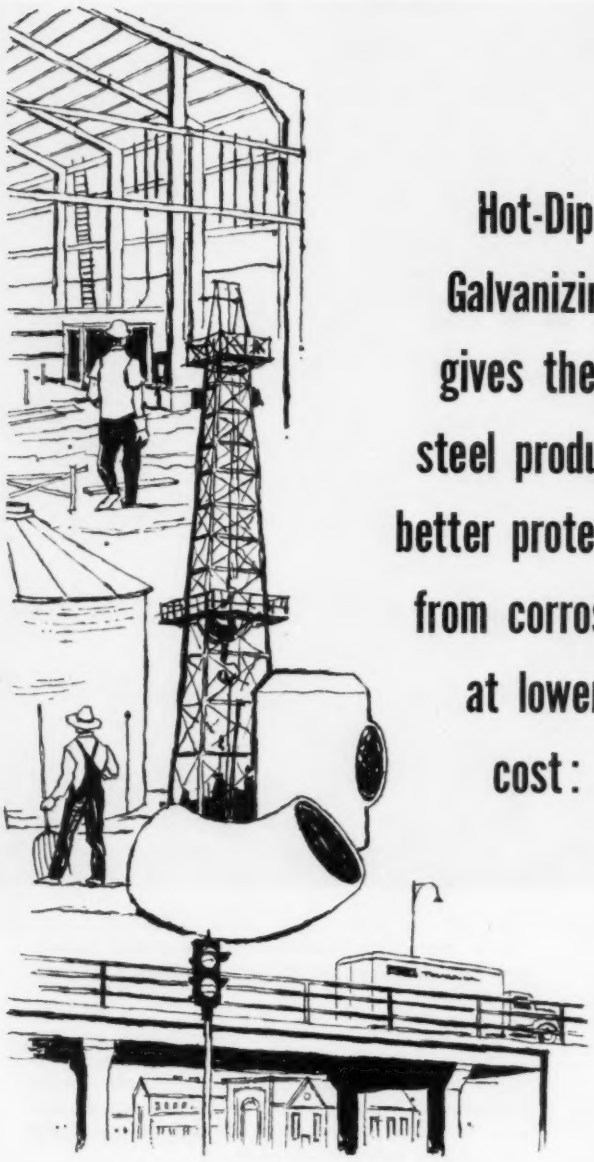

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Happenings . . .

to obtain the Ph.D. degree has been set up by The Dow Chemical Co. Under the program, the company will make several fellowships available to qualified employes each year. Interested employes may request a fellowship and leave of absence for the final year of work for the degree.

To qualify for a fellowship, the employe must indicate to the company that he has met language requirements for the Ph.D. degree, passed qualifying examinations admitting him as a doctoral candidate, been accepted by a professor for a definite thesis assignment and has a reasonable expectation of completing his work within one year of leave.

Solvent Survey Shows Major Problem Areas

A survey of 600 companies gave the problems of vapor toxicity and flash point the highest priority of matters needing attention in the field of cold cleaning. The ASTM Committee D-26 on Halogenated Organic (Cleaning) Solvents revealed the survey's results at a recent Chicago meeting. Both petroleum and halogenated solvents are involved, either straight or in mixtures. The survey showed the following items to be of interest, in the order listed: Vapor toxicity, flash point, evaporation rate or drying time, residue, corrosiveness, boiling point or range, solvent action on insulation, electrical conductivity, dermatitis, odor, cleaning ability, specific gravity, explosiveness of vapors, refractive index, acidity or alkalinity, and color.

Chicago To Be Scene of Next Four API Meetings

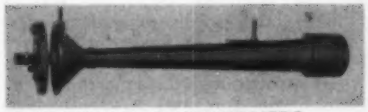
API annual meetings for the years 1960 through 1963, will be held in Chicago, according to the Executive Committee of API's board. The move ended speculation that the 1962 meeting might be scheduled for a West Coast city, and set the date and place for the 1963 meeting earlier than would have been done ordinarily. API feels that this will give more time for making arrangements. The 1960 meeting will be November 14-16, as set at Chicago last November. The other meetings will be: 1961, November 13-15; 1962, November 12-14; 1963, November 11-13.

Petrochemical, Refining Meet Scheduled for 1961

AIChE will sponsor a petrochemical and refining exposition in connection with the National AIChE meeting in New Orleans, February 26-March 1, 1961. The AIChE exposition will be managed by Reber Friel Co., Philadelphia. It was authorized by the Institute's council after careful study of suggestions from members in the petroleum and petrochemical industries. Its emphasis

For more data on advertised products, use Readers' Service Cards, last page.

How to select an industrial burner to meet your individual requirements



INSPIRATOR GAS BURNERS

(high pressure type)

Applications: Designed for use where natural or manufactured gas is available under *2 to 25 PSI*. These burners are economical at low cost for boilers, dryers, heaters, incinerators, industrial furnaces, kilns, petroleum processing and roasters.

Features: Gas energy used to inject combustion air; eliminates costly blower equipment. Adaptable to open port, sealed-in-wall or controlled secondary air firing. Offers flexibility, ease of control and efficient operation through simple, accurate construction. Adaptable for combustion safeguards.

Capacities: Nine sizes: from 80 to 24,000 cubic feet of gas per hour.

PORTABLE TYPE GAS BURNERS

Applications: Two models: one for intermittent, high output. The other is designed for moderate continuous operation. Applications: heating ladles, heating for bending or forming, firing small furnaces and portable benchwork.

Features: These burners are easily handled and weigh only 20 pounds each, including the low pressure gas burner, DFC motor blower and stand. Portable burners can be supplied with a rheostat for motor speed control.

Capacity: Maximum capacity is 500 cubic feet of 1,000 BTU natural gas per hour.

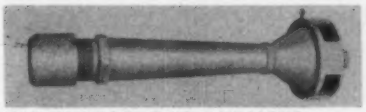
OIL BURNERS

(low pressure type)

Applications: to be used with light fuel oils and low pressure air, with blower, manually operated burners for use on dryers, heaters, industrial furnaces and roasters.

Features: Wide selection of fuel oils or distillates, from No. 1 to No. 4. Simplicity and flexibility through separate oil and air valves. Constant air volume and even burning by adjustable cone within burner body. Wide range of turndown.

Capacities: Five sizes vary from ½-gal. oil per hour under 10" water column, air pressure to 45-gal. oil per hour under 27"water column.



INSPIRATOR GAS BURNERS

(low pressure type)

Applications: This series supplements the high pressure inspirators where limited heat input per burner is required. Designed to burn all types of gas under low pressure. Applicable to dryers, industrial furnaces, preheaters and portable units.

Features: Inspirating effect of the throat induces sufficient combustion air. Simple, efficient, easy to control, eliminating costly blower equipment.

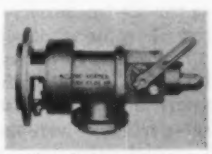
Capacities: Six sizes, from 4 to 420 cubic feet of gas per hour under pressures from 4" water column to 12" water column.

ATMOSPHERIC GAS BURNERS

Applications: Designed for any gaseous fuel under high draft conditions. Particularly where it is possible to build burner directly into brickwork. For use on dryers, incinerators, industrial furnaces and kilns.

Features: Flexible firing range, turn down ratio of 20 to 1; simple control by gas firing cock and revolving air shutter; excellent flame retention with fins molded into nozzle. Low installation and maintenance costs.

Capacities: Five sizes: from 150 to 10,000 cubic ft. of 1,000 BTU gas per hour at pressures over 1 PSI and high draft (.05" to .15" water column).



AUTO-RATIO OIL BURNERS

Applications: For use with heavy or light fuel oils with combustion air supplied by a blower. Applications: dryers, heaters, industrial furnaces, kilns, roasters.

Features: Single valve *automatically* proportions low pressure oil and air for combustion over its entire range. Wide selection of fuels including heavy preheated oil. Turn down ratios of 20 to 1 on larger sizes; 10 to 1 on smaller sizes.

Capacities: Four sizes: from 1.3 gallons of oil per hour under 10 ounces air pressure, to 25 gallons of oil per hour under 48 ounces air pressure.

CENTRIFUGAL MOTOR BLOWERS

Applications: The low pressure double inlet and the 16-oz. positive pressure single inlet series are used as source of combustion air for industrial burner systems.

Features: Low pressure blowers meet needs for smooth, quiet, inexpensive operation. 16-oz. positive pressure blowers create high discharge pressure, needed for a large turn down ratio and high efficiency.

Capacities: Low pressure series range from 100 CFM to 800 CFM. 16-oz. blowers range from 90 CFM to 1100 CFM.

BLAST TYPE GAS BURNERS

Applications: For use with manufactured or low pressure gas, with air supplied by a blower. Ideal for dryers, industrial furnaces, test furnaces and as preheaters.

Features: Low priced, manually controlled, blast type burner. Consists of gas-air mixer, blast air valve, cast iron nozzle and indicating cock. Mixer uses air from blower to entrain gas for delivery to burner.

Capacities: Six sizes, capable of burning from 280 cubic feet of 1,000 BTU gas under 2" water column pressure to 6,400 cubic feet of 1,000 BTU gas under 4" water column pressure.

Denver Fire Clay Company

3033 BLAKE STREET, DENVER 17, COLORADO

Please send me further information on DFC Industrial burners:

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COMPANY:.....

ADDRESS:.....

CITY.....**STATE**.....

DFO-1

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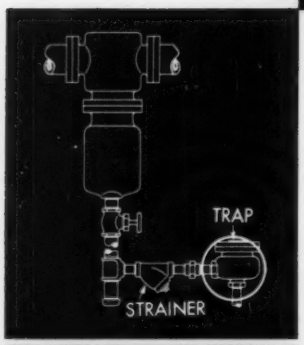
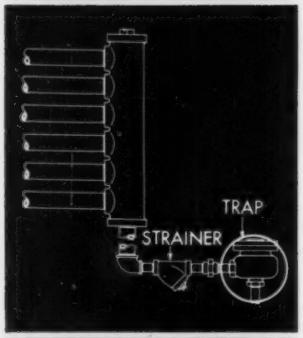
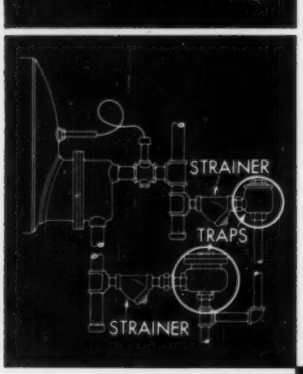
sure . . .

steam traps are a mere fraction of total steam equipment cost, but . . .







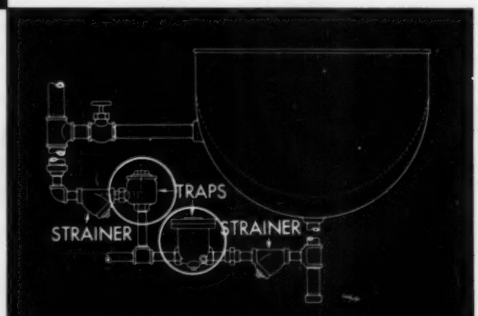
. . . what about your TOTAL thermal efficiency?

When you aren't getting top efficiency from your equipment . . . when leaking, dribbling steam waste lessens its full usefulness . . . when air or other non-condensables cause trouble . . . where do you look? Your steam traps! That's why it's mighty important that they (1) fully discharge condensate, air and other non-condensables promptly and (2) give long trouble-free service. Nicholson traps meet the first requirement because they operate on a *true balanced pressure* principle . . . and the second, because they only have one moving part, thus reducing the possibility of down-time. Other advantages are positive shut-off . . . high capacity . . . rigid pretesting.

Let's tell you more . . .

Write for Catalog

W. H. NICHOLSON and COMPANY
12 Oregon St., Wilkes-Barre, Pa.



Happenings . . .

will be on petrochemical and refining production, design and development.

The exposition will be held in conjunction with several days of technical sessions on chemical engineering in the production and processing of petroleum and petrochemical products. Both the exposition and the petroleum sessions emphasize the rapidly expanding interdependence of these industries and the chemical engineering profession. The technical program is being arranged by Howard Malakoff and A. I. Regnier, New Orleans, and a large committee of chemical engineers.

U.S. Senator Urges Loans For Latin Oil Projects

"There are sound loans that can be made to Latin American government oil projects, and they should be made," said Sen. Morse (D-Ore.) in a special report to the Senate Foreign Relations Committee. The report was on a study mission to five South American countries. Morse said that much of Latin America believes that U.S. oil firms have blocked loans to government oil projects. He added that the "only criterion for U.S. loans should be the soundness of the project, and no distinction should be made between loans to public and private enterprises."

Heat Transfer Conference To Be Held in August

The Fourth National Heat Transfer Conference and Exhibit, sponsored by AIChE and ASME will be held August 14-17 in the Statler Hotel, Buffalo, N.Y. In an effort to meet the needs of engineers working in the field, conference emphasis will be on practical, rather than theoretical aspects of heat transfer.

December Report on LPG Told by Bureau of Mines

The daily average production of natural gas liquids in December was 39.5 million gallons, an increase of two percent from November 1959, according to the Bureau of Mines. The daily average production of liquefied gases at refineries was 8.2 million gallons, four percent above November 1959. The daily average demand for liquefied gases for fuel and chemical use was a record high of 32.4 million gallons in December, nine percent above November 1959.

Stocks of liquefied gases totaled 873 million gallons, 145 million gallons above a year ago. Underground stocks of liquefied gases totaled 697 million gallons, a decrease of 178 million gallons during November.

Statistics for liquefied gases for 1959 are not strictly comparable with those for 1958 because of the better reporting

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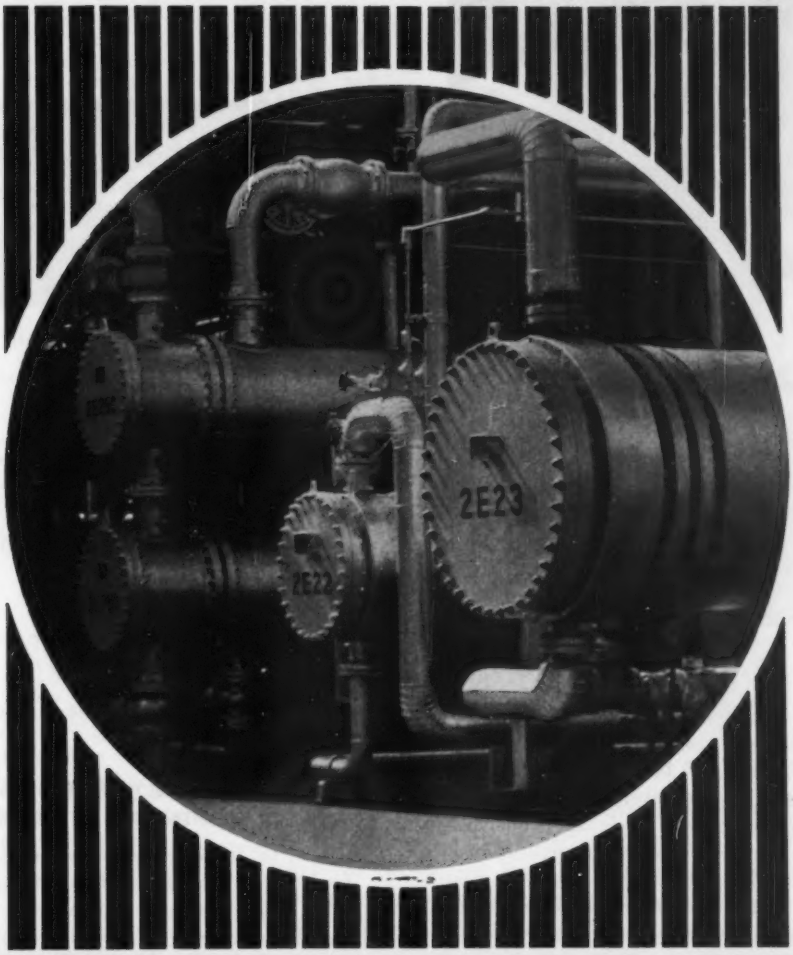

HEAT EXCHANGERS by CHIYODA

The newest time-saving methods plus the highest standards of fabrication result in dividend-paying equipment that is characterized by its precise, efficient operation and long life. Heat exchangers, coolers, condensers, and other process equipment, standard or special, large or small, single or by the scores, are fabricated at CHIYODA's new Kawasaki Factory with the most modern fabricating and testing equipment, using fabrication methods backed by years of experience. With an integrated organization staffed by specialists in every field plus lower man-hour costs, CHIYODA assures clients of early delivery, low maintenance cost, high operating efficiency and long life. For your process equipment requirements anywhere in the world . . . . . Contact CHIYODA.

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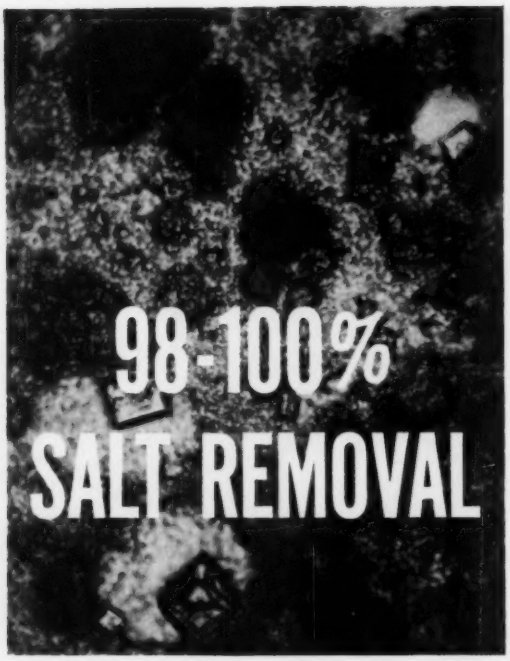

another
TRETOLITE SERVICE
report

with TRET-O-LITE *Desalting Chemicals*

It should be standard practice in modern refining to desalt any charge stream that contains 20 pounds or more of salt per 1,000 barrels of crude. Some refinery processes have an even lower salt tolerance—and permissible salt levels are constantly being revised downward. The proper application of TRET-O-LITE* Desalting Chemicals gives a clean charging crude that is 98–100% free of impurities, which would otherwise enter the refinery system and cause salt plugging in condensers, exchangers, and towers. There are important reasons why so many refiners prefer TRET-O-LITE Desalting Chemicals for this vital operation:

TRET-O-LITE DESALTING CHEMICALS ARE EFFECTIVE

Tretolite pioneering developed the first desalting system in which chemical alone provided emulsion destabilizing action. This leadership is maintained today through a never-ending research program which continues to find versatile new compounds capable of meeting every desalting condition.

TRETOLITE DETERMINES EXACT REFINERY NEEDS

Tretolite laboratory tests determine the TRET-O-LITE formulas and quantities that will desalt your particular crude most effectively. The Tretolite engineer is always available to handle new tests at site as they are required. Continuous, dependable salt removal is assured.

TRET-O-LITE Desalting Chemicals efficiently purify more than 1,500,000 barrels of crude every day, at an average cost of 1.3 mills per barrel. *Let the Man in the Red Car prove why Tretolite offers the best desalting service for your refinery.*

Equipment for Tretolite chemical desalting, as well as Petreco electric desalting, is designed and distributed by Petreco Division of Petrolite Corporation.

*Registered Trademark, Petrolite Corporation

TD-60-1

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MEXICO: R. E. Power, Sierra de Mijes, No. 125, Mexico, D. F.
NETHERLANDS: F. E. C. Jenkins, Hoefbladlaan 134, The Hague
PERU: Oilfield Import, S. A., Apartado 71, Talara
TRINIDAD: Neal and Massy, Ltd., P.O. Box 544, Port of Spain

For more data on advertised products, use Readers' Service Cards, last page.

of ethane in 1959. In 1958, ethane was included in "Other Mix." Natural gas liquids production in 1959 averaged 36.9 million gallons per day. Propane production in 1959 increased 12 percent over the final 1958 figures and butane increased 19 percent. The production of isopentane in 1959 was 69 percent above, and natural gasoline seven percent below 1958.

National Safety Congress Is Slated for Chicago

The 48th annual National Safety Congress will be held October 17-21 in Chicago. Sessions on industrial safety scheduled for the Conrad Hilton, Pick-Congress, Sheraton Towers, Morrison and La Salle hotels include traffic safety (Pick-Congress), commercial vehicle and transit safety (La Salle), farm safety (Palmer House), school and college safety (Hamilton), and home safety (Conrad Hilton).

Cost Engineers to Meet In Houston June 13-15

AACE will hold its annual meeting at the Rice Hotel, Houston, June 13-15. Technical papers and workshop sessions scheduled for the Houston meeting are as follows.

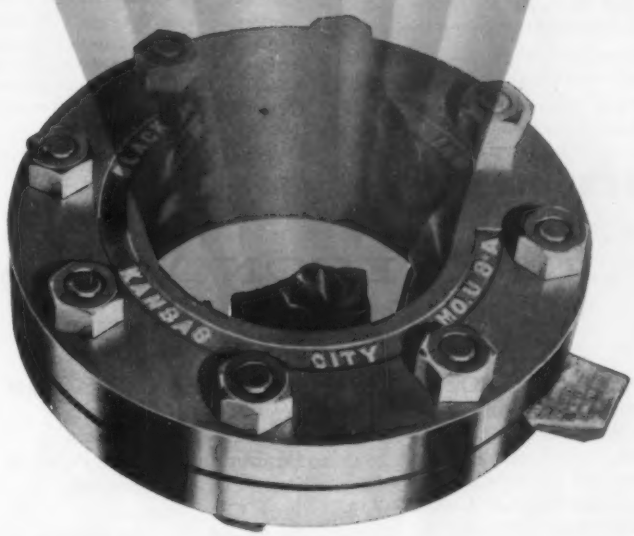
Papers. "Application of Computers to Capital Cost Estimating"—panel discussion by the Metropolitan New York Regional Section.

- "Statistics as a Tool for the Estimator"—S. A. Gertz, M. W. Kellogg Co.
- "Determination of Present Worth of Industrial Plants for Tax Purposes"—C. E. Lunsford, Pritchard & Abbott, Valuation Engineers.
- "Control and Reduction of Maintenance Costs"—R. I. Reul, Food Machinery & Chemical Corp.
- "Use Competitively Bid Lump-Sum Contracts to Reduce Chemical Plant Construction Costs"—G. McGovney, The Dow Chemical Co.
- "Estimating Productivity and Its Effect on Capital Construction Costs"—L. Dallavia, The Dallavia Co.
- "Short-Cut Method for Estimating Building Costs"—C. A. Miller, Canadian Industries, Ltd.
- "Research Aspects of Cost Engineering Education"—G. F. Schrader, M. S. Peters, L. F. Shaffer.
- "Unified Code System"—Dr. B. F. Gaffney and F. T. Weyerhaeuser.

Workshops and chairmen. "Planning a Short Course in Cost Estimating"—R. E. Barker, Continental Oil Co.

- "Evaluation of Chemcial Research Projects"—J. H. Perkins, Diamond Alkali Co.
- "Short-Cut Estimating Methods for Off-Site Facilities" and "Capacity Investment Estimating"—AACE Capital

This "heart-failure" can lengthen someone's life!



Pictured above is what happens when a pressure vessel protected by a BS&B Safety Head develops pressures above safe limits. "Heart" of the Safety Head is the rupture disc, which bursts to relieve the overpressure instantly and completely—guarding against injuries to personnel and damage to plant equipment.

BS&B Safety Heads

protect pressure systems in every type industry

Thousands of BS&B Safety Heads are today protecting millions of dollars worth of property and equipment and countless human lives. There's a BS&B Safety Head suitable for many types of pressure systems containing air, gas, steam or liquid.

BS&B Rupture Disc—"Heart" of the Safety Head

BS&B rupture discs are designed to relieve pressures at any specified point from 3 to 100,000 pounds per square inch. They are available in standard sizes ranging from ¼ inch to 36 inches in diameter, and in special sizes and types for virtually any application.

If you use any type of pressured system, let us tell you more about BS&B Safety Heads and rupture discs. Call or write your nearest BS&B office or representative—or write to . . .

BLACK, SIVALLS & BRYSON, INC.

Safety Head Division, Dept. 2-F5
7500 East 12th St.
Kansas City 26, Mo.

For more data on advertised products, use Readers' Service Cards, last page.

Happenings . . .

Cost Estimating Committee.

- "Capital Cost Terms and Definitions, Capital Cost Estimate Checklist, and Cost Records for Field Control and Estimate Feedback"—AACE Capital Cost Control Committee.
- "Profitability—Terms and Definitions and Methods of Evaluation"—AACE Profitability Committee.
- "Cost Indexes and AACE Cost Index Manual"—AACE Cost Index Committee.
- "Cost Control Procedure"—I. J. Bromberg, Foster-Wheeler Corp.

Submit Bill to Regulate Hazardous-Substance Labels

A model bill to regulate the labeling of hazardous substances used by the consuming public has been drawn up by the Manufacturing Chemists' Association, Inc., Chemical Specialties Manufacturing Association, National Paint, Varnish & Lacquer Association and API. The Senate Interstate and Foreign Commerce Committee reported favorably on the bill in March. Hearings on the bill by the House Safety and Health Subcommittee of the Interstate and Foreign Commerce Committee were held March 14.

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Bureau of Mines Releases Helium-Plant Cost Figures

Costs of building and operating the Bureau of Mines' two largest helium plants at Exell, Texas, and Keyes, Okla., are given in a report just placed on open file by the Department of the Interior. The report shows that the original helium plant at Exell, Tex., cost $4.16 million to construct in 1942-43 and that an addition to the plant in 1956-57 cost $4.7 million. The enlargement increased the plant's average helium-production capacity from 60 MMcf per year to 240 million. In fiscal year 1959, the Exell installation produced 273 MMcf of helium at a net cost of $9.88 per Mcf.

The new plant at Keyes, which went on stream last August, produced 85 MMcf of helium between that month and November, the report shows. The plant represents an investment of approximately $11 million and will produce about 290 MMcf of helium a year. During the operating period described in the report, the net cost of producing helium at Keyes was $8.57 per Mcf.

Prepared in response to requests from private industry, the report is designed to aid possible private producers in estimating costs of constructing new plants to process helium-bearing natural gases. Information on capital investment, labor requirements, operating conditions, and similar items is given for both the Exell and Keyes installations.

Copies of the report may be seen during regular office hours at the Bureau's Amarillo, Texas, helium plant; in the office of the general manager, Helium Operations, 514 Barfield Bldg, Amarillo; and in the office of the assistant director—Helium, Room 4627, Interior Building, Washington, D.C. The report is titled: "Information on the Cost and Operation of the Bureau of Mines Exell and Keyes Helium Plants."

Committee Week Records Second Largest Attendance

Just over 1,400 engineers and scientists—second largest attendance in the history of ASTM Committee Week—worked in Chicago during the week of February 1 to clean up the year's committee work in anticipation of the June annual meeting of the society. In five days' time, 35 of the society's technical committees held 351 meetings of subcommittees and working groups whose task it is to continually keep ASTM standards up to date.

The Society, which passed an enrollment of 10,000 members last October, gave special recognition to this event at the Committee Week dinner by presenting a special certificate to the 10,000th member, Robert J. McCallin, technical service supervisor, Medusa Portland Cement Co., Wampum, Pa. Certificates were also given to the 1,000th member,

A 0140-1

The pump must match the application

The available range of our RPK Process Pumps offers the Oil Industry a selection that fully meets the fundamental requirement stated above.

The special characteristics of this pump are maximum reliability and economical operation at all operating points. Other features are the wide range of capacities and applications, the ease with which erection and disassembly can be carried out, and parts subject to wear renewed. The design includes a high factor of safety.

The parts particularly liable to deteriorate by wear are standardized for the widest possible range of sizes, and thus the maintenance of an adequate stock of spares is greatly facilitated.

Every type of service is catered for in respect of shaft sealing, which may be by means of the conventional packed stuffing-box or one of a great variety of mechanical seals.

KSB

Klein, Schanzlin & Becker Aktiengesellschaft, Frankenthal (Pfalz) Germany

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STAINLESS STEEL TUBING

PATCO quality stainless steel tubing is the core of diverse heat exchanger systems for petroleum and petro-chemical industries. Our engineering and metallurgical staffs offer fundamental data on corrosion, physical properties and other factors which may assist you in your design and fabricating problems.

PATCO Stainless Steel Tubing, as well as PATCO Carbon and Alloy Steel Tubing, is produced in lengths up to 58 feet. Your orders are promptly shipped when sent to either Pacific Tube or your local Steel Service Center. Next time, specify PATCO Tubing.

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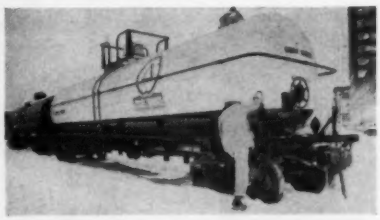
WESTERN REPRESENTATIVE FOR SUPERIOR TUBE CO.

Happenings . . .

Albert J. Loepsinger, director of research, Grinnell Corp., Providence, R.I., a member of the society since 1908. Harold Allen, U. S. Bureau of Public Roads, Washington, D. C., also received a certificate as the 5,000th member. He joined in 1943.

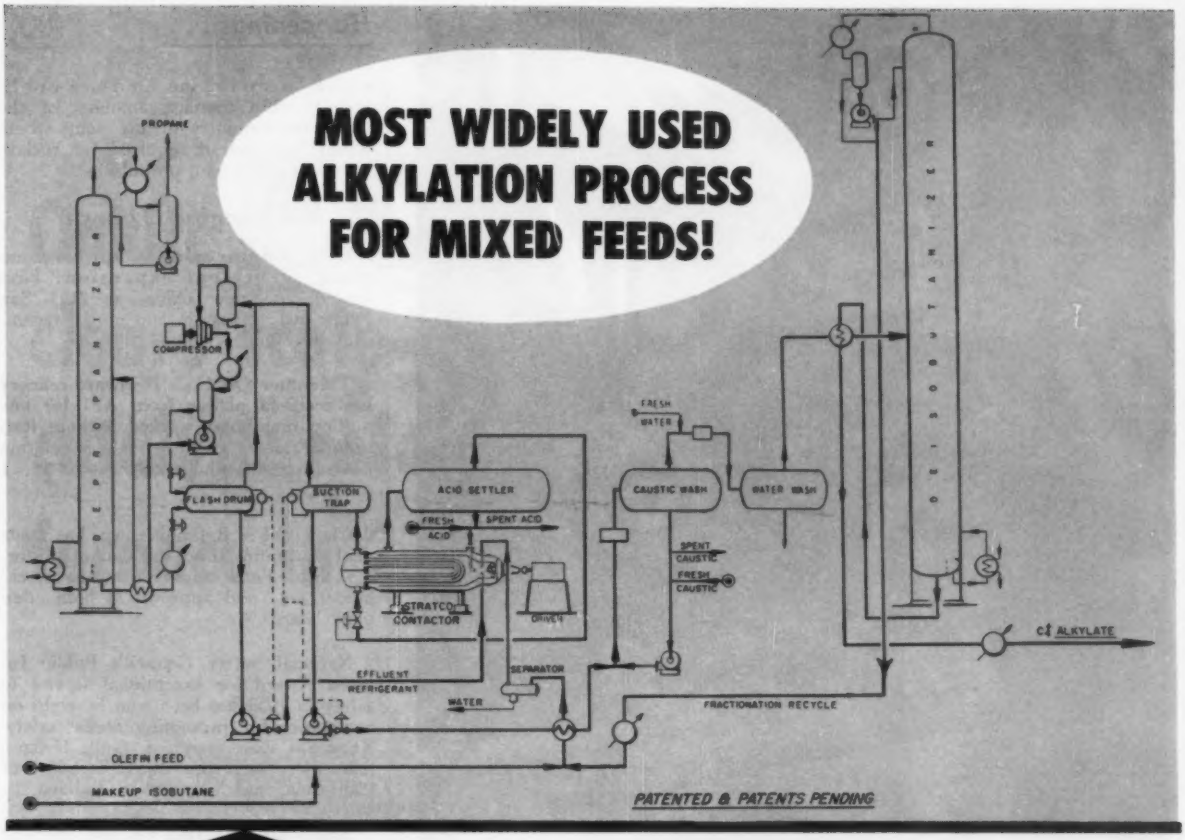
Tanker Trends



This 19,000-gallon tank car is one of a fleet of 100 jumbo tank cars just delivered to Cities Service Oil Co. It is engineered exclusively for LPG and anhydrous ammonia and is the largest of its type in operation. It is slightly more than 51 feet long and is fabricated of 13/16-inch high tensile steel. Although it is only 16 percent longer and 10 percent heavier, the car can transport 70 percent more product than the conventional LPG tank car.

The well-known holiday resort of Zermatt, Switzerland, famous for the Matterhorn, has no direct road access, and motor traffic is forbidden within the village. All transport from Brigue up the long and narrow mountain valley to Zermatt (5,970 feet above sea level) is by a narrow-gage railway. The fuel oil for the many hotels and guest houses arrives in special rail tankers and has to be distributed by a mule-drawn carriage in summer and by a sledge in winter.

The U. S. Air Force has put four 7,000-gallon liquid hydrogen tank trailers into service. Capable of hauling ultra-cold liquid hydrogen from coast to coast, they were designed and built by Air Products, Inc. With the new



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EFFLUENT REFRIGERATION* ALKYLATION

- **Best Economics**
- **Highest Alkylate Quality**
- **Lowest Acid Consumption**
- **Easiest Mechanical Operation**
- **Least Reboiler Fouling**

Since 1955, STRATCO effluent refrigeration alkylation has been installed in 27 plants in refineries throughout the world. Included are a large number of the currently predominant mixed propylene-butylene operations.

Of the total sulfuric acid alkylation capacity of approximately 327,000 BPSD, 145,000 BPSD is being produced in STRATCO equipment. In study after study, refiners have concluded that STRATCO offers the best solution to alkylate production.

**Licensed by Stratford Engineering Corporation*

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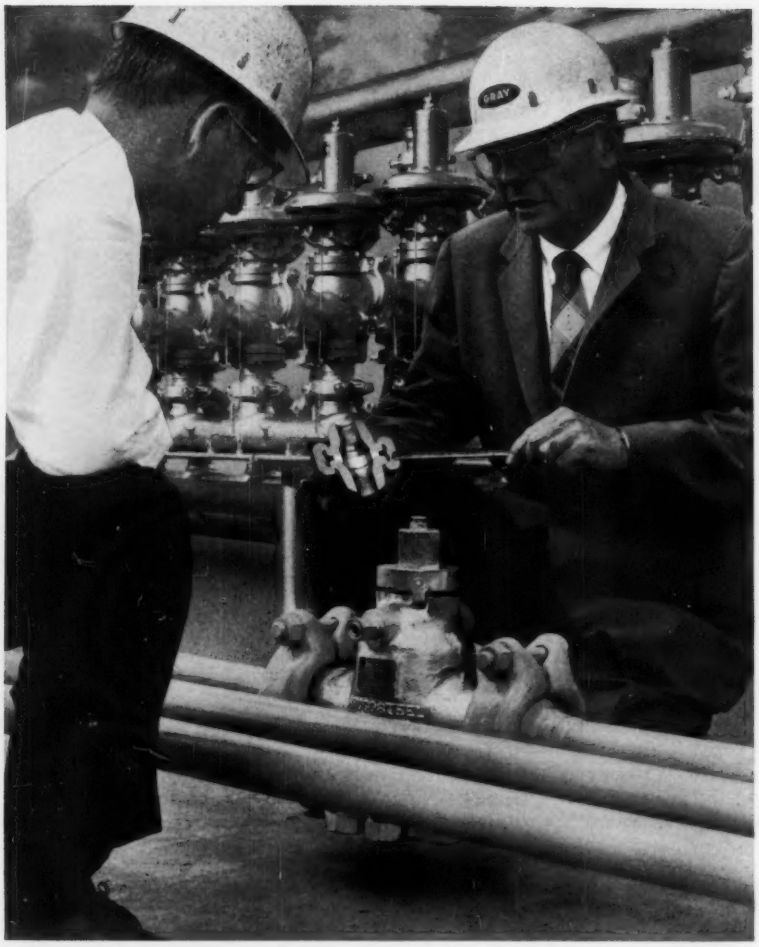

GRAYLOC® Seal: Leak-proof at any pressure

Leak-proof quality of GRAYLOC Seals in piping applications has been use-proved from full vacuum to 30,000 psi and test-proved up to 150,000 psi. Holding at any pressure makes GRAYLOC practical in applications requiring positive leak-proof connections.

The GRAYLOC Seal is available in two-bolt clamp-type or conventional flange connections. Its simple steel design features a rigid rib with lips on either side tapering slightly less than the mating hub to form a line seal at the touchpoint. As the connection is tightened, the lips deflect to form a surface seal. GRAYLOC connections provide a permanent steel seal that can be made up repeatedly, operating to pressure without seal ring replacement. Stock connections available from ½" to 30" and on special order in corrosion-resistant metals.

If you want to know more about how GRAYLOC Connections can permanently solve your leakage problems, write for the new GRAYLOC CATALOG on your company letterhead.

GRAY Tool Company

GRAYLOC SALES DIVISION

P. O. BOX 2291 HOUSTON 1, TEXAS Riverside 7-1240 05

Happenings . . .

trailers in service, the Air Force will be able to ship tonnage amounts of the liquid cross-country to any point where liquid hydrogen is required for rocket-testing and nuclear propulsion.

- Changing Times -

Delta Engineering Corp. has completed 50 percent expansion. Firm moved into new offices at 2121 San Felipe Rd., Houston, and added technical and office personnel.

Tidewater Oil Co.'s Delaware refinery has received plaque from API for one million man-hours worked without lost-time accident. At time of presentation hours worked without injury stood at 1.4 million.

Clark Oil & Refining Corp. has made deal to acquire Intex Oil Co., a California firm. Final approval awaits stockholder vote and approval of both company boards.

National Safety Council's Public Interest Award for exceptional service to safety in 1959 has been won by eight oil companies for promoting traffic safety. They are Esso Standard, Gulf, Hedges, Schneider, Shell, Speedway, Standard of California, and Standard of Indiana.

Signal Oil and Gas Co. has received increase in import allocation for districts I to IV through settlement of litigation with Justice Department. The 1,439-bpd increase became effective April 1.

Next WPRA computer conference comes up this month—the 24th and 25th at Ben Milam Hotel, Houston.

New "fuel brick" produced by mixing liquid butane with urea-formaldehyde resin, polyvinyl alcohol, casein and gly-

FOR OIL AND PHENOL ANALYSIS
in water effluents

Now the ULVIR-MOD 2834 makes possible rapid analysis using API methods 717 and 733. This "colorimeter type" spectrophotometer is equipped with an

f 4/5 optical system
9 millimicron bandwidth
at a cost of only $1,800.

For detailed information, write for circular 34.

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Manufacturers of Precision Optical Instruments, Filters and Thin Films

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Oakite ECP
engineered cleaning program

clears scale-choked catalytic reformer furnace in 2 days

Sulphur-platinum-carbon scale cut heat-transfer ability so severely that a catalytic reformer furnace was operating below capacity. Gasoline production dropped sharply. Moreover, the all-welded unit couldn't be dismantled for manual cleaning.

That prompted a call for the Oakite engineer. In developing an ECP, he recommended circulating a solution of specific Oakite Compounds through the choked tubes. The two acidic materials used as recommended were safe for the low chrome steel furnace tubes. This solution was circulated for four hours through each of the four sections of the furnace: convection, preheat, #1 reheater and #2 reheater. It took just two days to descale the tubes completely, putting the reformer unit back to producing over 3000 barrels a day.

WHAT IS OAKITE ECP? It's an *Engineered Cleaning Program* that stresses chemical cleaning. It's engineered specifically for your refinery, for your cleaning problems, and for each cleaning operation—tower by tower, valve by valve.

The Oakite engineer lends personal and experienced supervision to each phase of the program. He supplies detailed instruction based on practical knowledge of refinery cleaning needs. Each Oakite ECP is backed by a *laboratory* concentrating on chemical cleaning research, by *materials* known to make short work of refinery soils, by proved *methods*. Send for booklets. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

OAKITE

over 50 Est. 1909 SCIENCE

years' leadership in industrial cleaning

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Oakite ECP

your economy key

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SULPHURIC ACID

to 1/10th of 1%

Tailor-made for YOUR Process

as delivered

Do you use 100.3%? Or 96.1%?

You name it and we deliver it ready for your processing line.

What's more... deliveries are prompt and dependable. Consolidated's big fleet of tank cars, trucks and barges is handled by an exceptionally skilled traffic department. Movements are traced day by day ...and we load and start shipments so they reach you on time.

And don't forget... if spent sulphuric acid is one of your problems, our regeneration facilities at Houston and Baytown, Texas; at Baton Rouge, La., and Hammond, Indiana, are the largest in the world. Virgin water-white H_2SO_4 from any processable acid we can pump out of barge, car or truck!

Sulphuric Acid is also shipped from Ft. Worth and Corpus Christi, Tex., LeMoyne, Ala., Los Angeles and Richmond, Calif., and Tacoma, Wash.

Stauffer CHEMICALS SINCE 1885

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Changing Times

(continued)

cerin so as to produce gas imprisoned in bubbles, has been developed by U.S.S.R. scientists. Russians claim brick lights easily and burns smoothly—can be shipped on flatcars.

Spanish government has denied application by Cia. de Petroleos de Galicia for authorization to build refinery at Vigo. Plant didn't conform to government policy toward national oil industry, under which government must be largest shareholder.

Three more countries have joined ranks of International Federation of Petroleum Workers—Switzerland, Tunisia and Gambia. Move involves about 6,000 workers.

Venezuela has approved formation of state-owned oil company, Venezuelan Petroleum Corp. Company will be government dependency attached to Ministry of Mines and Hydrocarbons. **It will have own legal status and patrimony** independent of national treasury.

Pacific State Oil Co., Billings, Mont., has acquired Queen City refinery, Dickinson, N. D. Company plans to reopen plant within a month to produce jet fuel and, at later date, motor gasoline.

Signal Oil and Gas Co. has changed name of its Eastern States Petroleum and Chemical Co. Division to Houston Division. Eastern States merged with Signal last September.

Crude Oil production in the U.S.S.R. during first quarter, 1960, averaged 2.84 million bpd—a 16 percent gain over corresponding 1959 quarter. Gas production was up 30 percent.

The Pure Oil Co. has assumed control of Woodley Petroleum Co. Assets gained include Woodley's 38 percent interest in **35,000-bpd refinery** run by Great Northern Oil Co. in St. Paul, Minn.

Hercules Powder Co. and A. C. Hatrick, Ltd., Australia, have formed jointly owned Australian company, Hercules Powder Co. (Australia) Pty., Ltd. Firm will make industrial chemicals for New Zealand and Australia.

Bay Petroleum Co., Division of Tennessee Gas Transmission Co., has changed name to Tennessee Oil Refining Co. Name was changed to "more closely identify division with Tennessee Gas.

After-tax petroleum refining profits in 1959 totaled $2.63 billions—up 6.4 percent from 1958, says Securities Exchange

this Catawissa Cup–Orifice plate

CONVERTS

any standard CATAWISSA UNION

into a gasketless ORIFICE UNION

with satisfaction fully guaranteed!

Here is real ECONOMY, SIMPLICITY and DEPENDABILITY for metering, measuring, controlling any piped material!

Catawissa Cup-Orifice Unions were placed on the market during 1958 to field-test research findings. User reports came back with higher than expected compliments and orders poured into the factory!

Now, the full economy story can be told! Orifice Union problems of the past are gone forever! Inventory is simplified, because you can convert any standard Catawissa Union into a gasketless orifice union. Your choice of a stainless or carbon steel cup-orifice plate (blank or drilled) fits easily, quickly, securely in place between the union head and tail pieces to form a good, tight, leakproof seal!

Temperature and pressure requirements are now governed by the rating of the union itself (3000-lb service, 9000-lb test)!

Just specify "Catawissa Cup-Orifice Plates" or "Catawissa Cup-Orifice Unions" at your favorite supply store — or write direct for free catalog and complete information.

PIPE UNION SPECIALISTS — SINCE 1917

CVF CATAWISSA VALVE & FITTINGS CO.

CATAWISSA • PENNSYLVANIA

For more data on advertised products, use Readers' Service Cards, last page.

ELLIOTT air magnetic tube expander drives

automatically controlled for fast, accurate tube rolling

Designed for faster, precision tube rolling, the standard model Elliott Air-Magnetic drive is setting new records for speed and accuracy. Some operators average 12 tubes per minute. Desired torque easily preset by rotating forward end of unit. No tools needed. Rolling stops when preset torque levels are reached. Includes trigger-controlled, explosion-proof air motor in single unit. Magnetic control, no springs. Balanced for easy handling. For tubes ¼ in. through 3 in. *Standard model* handles most jobs. *Heavy-duty* for higher torque.

ALSO Electric Control ... Tube Expanders ... and Related Accessories

Elliott offers the Automatic Electric Control—an accurate torque-limiting device designed for tube expanding with any standard tapping motor. Also, a complete line of tube expanders, with rotating, parallel, self-feeding rolls. Available in 4 sizes, ranging from ¼ in. to 3½ in. O.D.

Other related accessories include Elliott tube gage, tube plugs, tube pilot, and tube rolling lubricant.

Write for descriptive literature *today*.

Y9-3

ELLIOTT Company
LAGONDA PLANT, Springfield, Ohio

Changing Times

(continued)

Commission and Federal Trade Commission. After-tax profits for fourth quarter dropped 11.9 percent below fourth quarter, 1958.

Esso Standard Oil Co. is introducing new motor oil which company claims will keep engines cleaner than other premium motor oils. **Oil was developed with aid of computer and use of radioactive tracers.** It breaks engine-formed sludge into minute particles, which are held in suspension. When oil is drained—out goes sludge.

Motor fuel sales taxes collected in fiscal year 1959 totaled $3.06 billion, up 4.8 percent from the $2.92 billion for fiscal 1958, says Commerce Department. Motor fuel taxes were second most lucrative levy for states, following general sales and gross receipts taxes.

Bill requiring all cars sold in California to have exhaust-control device, as soon as two such devices are certified by state as satisfactory, has been sent to governor for signature. In Los Angeles, Air Pollution Control District director said **move should end smog problem** in "five or six years."

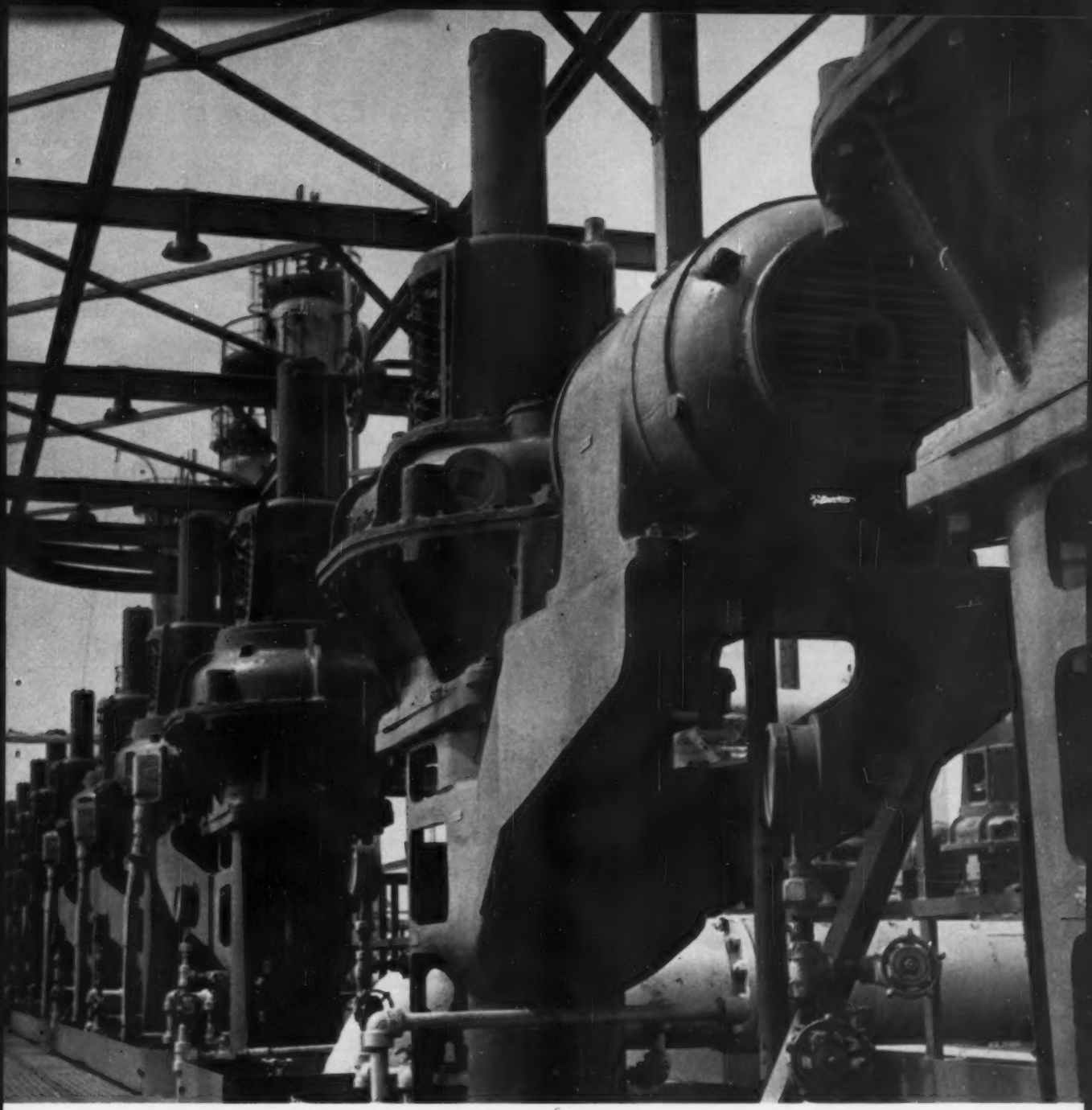
Cities Service Co. has acquired ⅓ interest in ABC-Petrolifera Italiana S.P.A., large Italian petroleum marketer. Acquisition will be through Cities Service subsidiary, Peruvian Pacific Petroleum Co.

STORAGE TANK VENT DRIER

This inexpensive drying column will absorb all water vapor from air entering a tank. Moisture sensitive liquids may be stored without contamination by water vapor. Details on request.

W. A. Hammond Drierite Co.
120 Dayton Avenue, Xenia, Ohio

For more data on advertised products, use Readers' Service Cards, last page.



The new look in alkylation

Breaking the skyline at Linden, N. J., is a new silhouette. It's the outline of 42 big 50-hp LIGHTNIN Mixers atop huge alkylation reactors at Esso Standard Oil Company's Bayway refinery.

These mixers deliver a powerful, steady turbulence that instantly disperses incoming olefins, keeps hydrocarbons from separating anywhere in the reactor, promotes maximum acid economy and light alkylate yield. The mixers operate continuously, 24 hours a day.

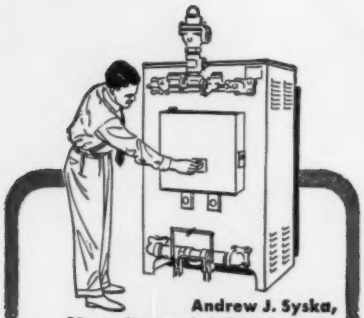
To the success of this process MIXCO engineers contributed many hours of research into the fluid mechanics of alkylation, and specialized knowledge of mixer impeller performance under varying reactor conditions.

When you are designing a process or fitting out a plant, you can count on the same skills—in fluid mechanics and in equipment design—to minimize your operating costs. Your LIGHTNIN Mixer representative can give you full details. Or write to us in confidence.

Lightnin® Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 164-e Mt. Read Blvd., Rochester 3, N. Y. In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont



Andrew J. Syska,
Hayes Research & Development Engineer Reports . . .

KNOW-HOW IS VITAL IN GAS AND LIQUID DRYING

When we developed the Molecu-Dryer®—a unit specially designed to take advantage of the remarkable drying, sweetening, and purifying capabilities of Linde Company's Molecular Sieves—our chief interest was in drying protective atmospheres (hydrogen, dissociated ammonia, etc.) for metallurgical work—to dewpoints well below –100°F. A natural outgrowth of the Molecu-Dryer was the *Nitro-Gen***—an automatic cycling generator which produces low cost, high purity nitrogen for blanketing, purging, protecting. Our engineering people have also explored whole new worlds of gas, liquid, and atmosphere drying and separating problems.

NEW DRYING NEEDS APPEAR DAILY

In manufacturing transistors, for example, the Molecu-Dryer has been able to effect big economies by supplying moisture-free air in place of tank nitrogen to protect transistor assembling and sealing operations. Other current projects: instrument air drying, gaseous CO_2 drying, gas separating . . . also drying and separating of liquid or gaseous hydrocarbons.

EQUIPMENT DESIGN IS DYNAMIC!

Each new area of work has necessitated engineered application of standard or special Molecu-Dryer models, to provide optimum adsorption efficiency, top capacity at minimum equipment cost, job-coordinated cycle times, and fast desorption and cooling.

Linde MOLECULAR SIEVES

For a comprehensive picture of the Molecu-Dryer, write for Bulletin 5703.

*Hayes TM

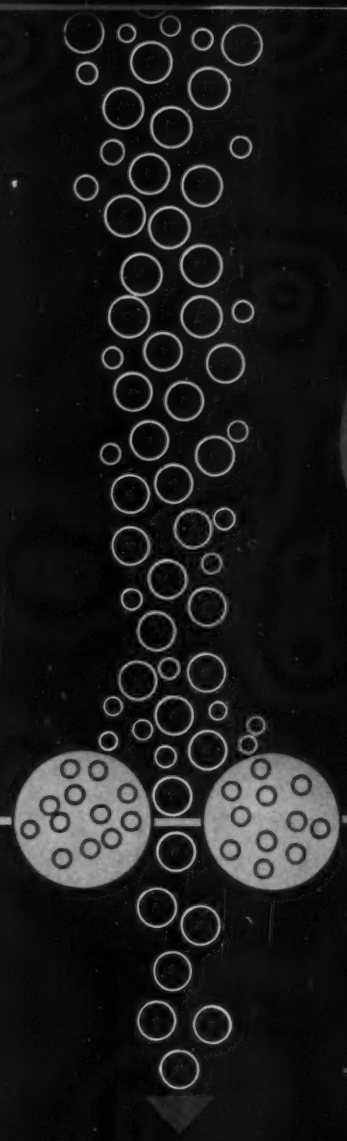
C. I. HAYES, INC.
853 Wellington Avenue • Cranston 10, R. I.
Established 1905

ELECTRIC FURNACES

It pays to see HAYES for metallurgical guidance, laboratory facilities, furnaces, atmosphere generators, gas fluid dryers.

Meetings Calendar

May	
22–26	**American Society of Mechanical Engineers,** Oil and Gas Power Conference and Exhibit, Muehlebach Hotel, Kansas City, Mo.
22–26	**Air Pollution Control Association,** Annual Meeting, Netherland-Hilton Hotel, Cincinnati.
23–26	**Design Engineering Show,** New York Coliseum.
26–27	**Rocky Mountain Oil & Gas Association,** Annual Meeting, Refining Committee, Newhouse Hotel, Salt Lake City, Utah.
June	
1– 3	**Instrument Society of America,** Annual Instrumental Methods of Analysis Symposium, Queen Elizabeth Hotel, Montreal, Canada.
1– 3	**Southern Gas Association,** Annual Short Course in Gas Technology, Lewis Hall, Texas College of Arts and Industries, Kingsville, Texas.
5–10	**ASME,** Semi-Annual Meeting and Aviation Conference, Statler Hilton Hotel, Dallas.
5–10	**Society of Automotive Engineers,** Summer Meetings, Edgewater Beach Hotel, Chicago.
13–15	**American Association of Cost Engineers,** National Meeting, Rice Hotel, Houston.
13–17	**Technical Writers' Institute,** Rensselaer Polytechnic Institute, Troy, N.Y.
15–16	**Western Petroleum Refiners Association,** Mid-Continent Regional Technical-Industrial Relations Meeting, Hotel Lassen, Wichita, Kan.
19–22	**American Institute of Chemical Engineers,** Meeting, Del Prado Hotel, Mexico City.
25-Jul 5	**ISA, AACC, ASME, AIEE, IRE, AIChE,** International Congress for Automatic Control, Moscow, U.S.S.R.
26-Jul 1	**American Society for Testing Materials,** Annual Meeting and Apparatus Exhibit, Chalfonte-Haddon Hall, Atlantic City.
Aug.	
15–17	**ASME-American Institute of Chemical Engineers,** Heat Transfer Conference and Exhibit, Statler Hilton Hotel, Buffalo, N.Y.
Sept.	
7– 9	**ISA, ASME, AIEE, IRE, AIChE,** Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Mass.
11–16	**American Chemical Society,** National Meeting, New York.
14–16	**National Petroleum Association,** Annual Meeting, Hotel Traymore, Atlantic City.
–15	**Natural Gasoline Association of America,** Rocky Mountain Regional Meeting, The Palliser Hotel, Calgary, Alba., Canada.
15–16	**ASME,** Engineering Management Conference, Hotel Morrison, Chicago.
18–21	**ASME,** Petroleum Mechanical Engineering Conference, Jung Hotel, New Orleans.
21–23	**ASME-AIEE,** Power Conference, Bellvue-Stratford Hotel, Philadelphia.
25–28	**AIChE** Meeting, Mayo Hotel, Tulsa.
25–28	**American Institute of Electrical Engineers,** Electrical Conference of the Petroleum Industry, Hotel Skirvin, Oklahoma City.
26–30	**American Welding Society,** National Fall Meeting, Hotel Penn-Sheraton, Pittsburgh.
26–30	**ISA,** Fall Automation-Instrument Conference and Exhibit, Annual Meeting, New York Coliseum, New York.
Oct.	
6– 7	**National Association of Corrosion Engineers,** Annual Western Region Conference, Sheraton-Palace Hotel, San Francisco.
6– 8	**NACE,** Southeast Region Conference, Dinkler-Plaza Hotel, Atlanta, Ga.
9–12	**ASME,** Rubber and Plastics Conference, Lawrence Hotel, Erie, Pa.
10–11	**ASME-AIEE,** Fuels Conference, Daniel Boone Hotel, Charleston, W. Va.
11–14	**NACE,** Northeast Region Conference, Prichard Hotel, Huntington, W. Va.
13–14	**California Natural Gasoline Association,** Fall Meeting, Hotel Miramar, Santa Monica, Calif.
25–28	**NACE,** South Central Region Conference, Mayo Hotel, Tulsa.
Nov.	
14–16	**American Petroleum Institute,** Annual Meeting, Conrad Hilton, Palmer House, and Congress Hotels, Chicago.
27–Dec. 2	**ASME,** Annual Meeting, Statler Hilton Hotel, New York.
Dec.	
4– 7	**AIChE** Meeting, Hotel Statler, Washington.
7–11	**NACE,** University of Illinois Corrosion Control Short Course, Urbana Campus.



One-stage purification delivers

ETHYLENE WITH LESS THAN 1PPM OF CO_2

...WHEN YOU ADSORB WITH LINDE MOLECULAR SIEVES

This is only one of many applications which utilize the high capacity and selectivity of LINDE Molecular Sieves. In fact, Molecular Sieves not only outperform other adsorbents, but do other adsorption jobs never before accomplished. Whether in new installations or as replacement adsorbent in existing units, Molecular Sieves can help you minimize both investment and operating costs. More specifically, here's how they are used. . . .

A major petrochemical company has reduced the CO_2 content of its ethylene from 3000 PPM to less than 1PPM. This high purity is achieved in a single-stage process, automatic and non-corrosive, which has proved to be more economical than the alternative four-stage process. Other petrochemical uses include drying of cracked gases, ethylene, hydrogen, liquid propylene, solvents and many other gases and liquids. **Natural gas producers** use Molecular Sieves for drying and sweetening of natural gas, for sweetening of liquid propane and butane, and for drying of adsorber oil. **Petroleum refiners** use them to gain efficiency in drying reformer hydrogen, liquid butane LPG and transformer oil, and for removal of impurities such as CO_2 and mercaptans. **Refrigeration manufacturers** use Molecular Sieves as a desiccant in super-drying refrigerants to eliminate freeze-up and corrosion.

For these and many other adsorbent applications, you can rely on patented LINDE Molecular Sieves to perform more effectively. They are the top quality material of their kind available today, always uniform, with high capacity, high strength, and high bulk density. They are available in regular and special grades to meet your specifications.

LINDE technical know-how—gained from years of laboratory and field work with adsorption problems—can help make Molecular Sieves work profitably for you. For further information, write: Dept. PR-05 Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, New York. **In Canada:** Linde Company, Division of Union Carbide Canada Limited, Toronto 7, Canada.

SOME AREAS WHERE MOLECULAR SIEVES IMPROVE ADSORPTION

- Purification of ethylene
- Drying gases, liquids, solvents
- Drying, sweetening natural gas
- Sweetening liquid propane, butane
- Drying jet fuels
- Octane improvement
- As refrigerant desiccant
- Controlled atmosphere purification

LINDE COMPANY

UNION CARBIDE

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Men In Industry...

NGAA Presents Hanlon Award To Phillips' Earl Hachmuth

The Hanlon Award, highest honor in the natural gasoline industry and one of the ranking awards of the petroleum industry, has been conferred on Karl H. Hachmuth, staff consultant, Research and Development Department, Phillips Petroleum Co., Bartlesville, Okla. He is the 24th recipient of the Hanlon Award—conferred annually by the NGAA for outstanding service to the natural gasoline industry.

The citation read in part: "We are honoring this man today because his ever curious mind, his imaginative approach to the problems of hydrocarbon chemistry, and whose fundamental chemical engineering studies combined to benefit the industry. More specifically, we are recognizing his long and continued work in the development of equilibrium ratio and enthalpy data and his practical application of that data in extraction and separation processes. His experimental determinations led to basic concepts which have resulted in great advances in petrochemistry and to new and useful products from natural gas liquids." With Phillips since 1927, Hachmuth earned a degree in chemical engineering at the University of Michigan from which he graduated in 1925.

Earl H. Hachmuth

Kenneth C. Loughlin has been elected president of Celanese Corp. of America, succeeding **Harold Blancke.** Since December 1956 he had been executive vice president. Blancke will continue to serve as chairman and chief executive officer of the corporation. Loughlin has spent most of his working career with Celanese, joining the organization in 1929 following graduation from North Carolina State College, where he obtained a B.S. degree in textile chemistry and dyeing. During his first three years with the company, he did laboratory and sales work in Charlotte, N.C. Between 1932 and 1951, Loughlin served as Southern District sales manager, covering a 12-state area. In 1951, he was appointed vice president of the southern fibers sales. The following year he became vice president and general manager of the Celanese Fibers Division, serving in that capacity until his appointment.

D. R. Johnson, Houston, has been named vice president of Continental Oil Co. He is general manager of Continental's Manufacturing Department. Johnson received his bachelor's degree in electrical engineering in 1923 from the University of Colorado and joined Conoco the following year at Glenrock, Wyo. He was assistant superintendent of the company's Glenrock refinery before transferring to Ponca City, Okla., in 1929 as refinery inspector supervisor. He served in key positions at Conoco's largest refinery at Ponca City before his promotion to superintendent of that plant in 1942. Six years later he became regional refinery manager for the company's Southern Region. He was promoted in 1949 to general manager of the Manufacturing Department which he will continue to supervise.

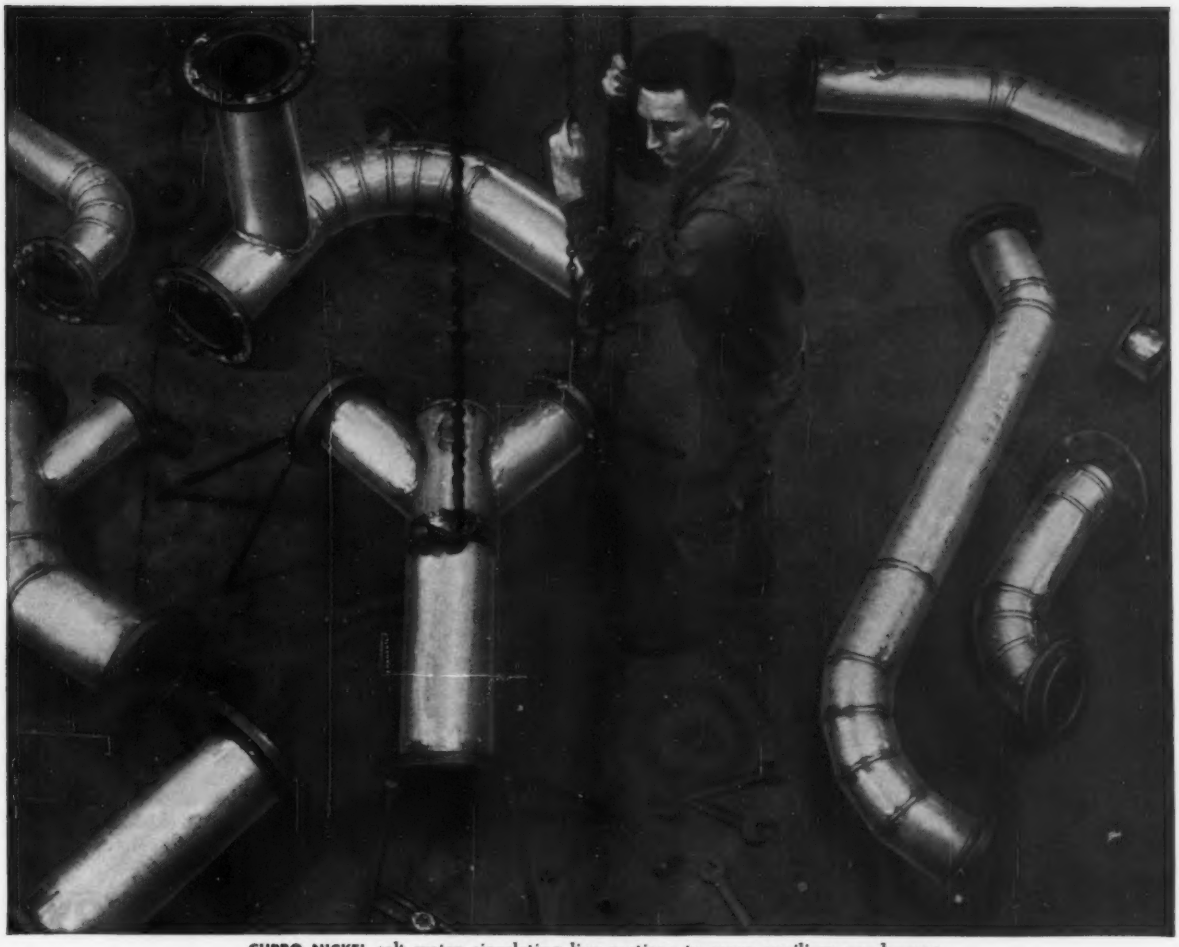
David L. Eynon, Jr., was elected chairman of the board, and **John A. Scott** was named president at the first meeting of the board of directors, Sinclair-Koppers Chemical Co. Other officers elected were: **C. W. Hardell** and **Carl H. Pottenger,** vice president; **John M. Crimmins,** secretary; **C. W. Hardell, T. C. Cochran** and **J. Von Bevern,** assistant secretaries; **J. P. Downer,** treasurer; and **R. H. Hein** and **K. C. King,** assistant treasurers and assistant secretaries. Members of the board, named by Sinclair and Koppers, are: **John A. Scott, R. E. Howe, E. J. Anglin** for Sinclair and **David L. Eynon Jr., Walter P. Arnold** and **James M. Veeder** for Koppers.

Dr. George A. Weisgerber has been named a research associate in the Products Research Division of Esso Research and Engineering Co. Associated with research projects concerned with the development and application of petroleum-derived wax, he has been with Esso Research since 1951. He holds a doctorate degree in organic chemistry from the University of Delaware, where he also earned a master's degree. In addition, he was awarded a bachelor's degree in chemistry from Philadelphia College of Pharmacy and Science.

Ben A. Lovell has been appointed gas coordinator for Sunray Mid-Continent Oil Co.'s Central Division. He joined Sunray in 1950 as a junior engineer in Benton, La. Before his promotion he served as district engineer for Sunray's Western Oklahoma District headquartered in Oklahoma City. Lovell graduated from Louisiana Polytechnical Institute with a degree in chemical engineering. In his new position, he will advise and assist in administering division gas contracts, plant operations and utilization of gas production within the Central Division.

Robert L. Gillis has been appointed assistant to executive vice president **Robert C. Gunness** of Standard Oil Co. (Indiana). Sales promotion and advertising manager of the Southeastern Sales Region, Indianapolis, Ind., he succeeds **Hamilton P. Dendel,** who is being transferred to American Oil Co., an affiliate. Gillis joined Standard in 1947 at Peoria, Ill., as supervisor of real estate, taxes, and claims.

Randolph M. Bailly has been named a section head in the Process Research Division of Esso Research and Engineering Co. He is in charge of the division's Operations Section, and is concerned with pilot plant operators, clerical and other supporting personnel. Bailly joined Esso Research in 1948. His initial work was



CUPRO NICKEL salt water circulating line sections to serve auxiliary condensers aboard gypsum rock carriers recently fabricated by Boro Marine & Industrial Corp.

Wide variety of Cupro Nickel piping for salt water lines is readily made from sheet by welding

Circumferential joints are welded manually. Longitudinal seams are welded in mechanized equipment by inert-gas, metal-arc processes.

Ever higher velocities in salt water lines and the growing economic importance of continuity in service, on shipboard, and also in tidewater power plants and oil refineries, are leading to increasing use of Cupro Nickel in piping.

Techniques and skills for economical fabrication of even the most complicated elements of Cupro Nickel piping systems are keeping pace. Boro Marine & Industrial Corp., Port Richmond, Staten Island, N. Y., a specialist in the field, forms piping in sizes 6″ to 24″ diameter from Anaconda Cupro Nickel stock sheet, usually 48″ x 96″ x 3/16″. Elements shown above indicate the variety possible. Seamless tubing is used for smaller diameters.

Boro Marine fabricates piping from both Cupro Nickel 30%-702 and Cupro Nickel 10%-755. The trend, however, is to Cupro Nickel 10%-755 for the majority of salt water line installations on commercial vessels and in industrial jobs, according to M. E. Wuensch, president. The alloy was developed by Anaconda for this kind of service. It is resistant to corrosion by both clean and polluted sea water, even at relatively high velocity of flow, and is resistant to corrosion by sea water containing air bubbles.

TECHNICAL ASSISTANCE. For help in selecting the alloy best suited for a particular job in heat transfer and piping systems, call in your American Brass representative, or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

ANACONDA®

CUPRO NICKEL MILL PRODUCTS

Made by The American Brass Company

Arrangement of burners (left) assures even heating of tubes (right) in Selas gas reformer. This, plus the use of iron-chromium-nickel alloy, is expected to boost tube life to ten years . . . or more . . . in California plant.

Uniform heat and nickel stainless steel prove keys to long tube life in gas reformer

What causes short tube life in gas reforming furnaces?

"Flame impingement," says one operator. "Local hot spots during decoking" says another. "Improper selection of metals" says a third.

Although there are no easy answers to the complex problems posed by heat, corrosion and stress, advances in metallurgy and design are making possible greater economy in furnace operation.

Tube life is being sharply increased

Gas reformer tube life is being upped, today, to the point where some operators anticipate ten years or more service. That is the life California Ammonia Company expects, for example, after the first year of operating their Lathrop, California, anhydrous ammonia plant.

One reason for this, they say, is the design of their Selas furnace. It provides for individual control of recessed, radiant-heat burners. Thus Calamco can "organize" heat within the furnace for fast initial heating of feed and for uniform controlled heating of catalyst tubes, without flame impingement.

Calamco and Selas agreed on the use of iron-chromium-nickel cast alloy A.C.I. Type HK for the tubes. This 20% Nickel, 25% chromium alloy provides excellent resistance to hot gases, including sulfur bearing, under both oxidizing and reducing conditions and is one of the stronger heat-resisting materials.

If the life of furnace components in your plant is not what you desire, look into the properties of nickel-containing casting alloys. Our new booklet, "Heat- and Corrosion-Resistant Castings . . . Their Engineering Properties and Applications" makes this easy. We'll be glad to forward a copy at a word from you.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

Spring suspension frees tubes to expand. Nickel alloy provides strength at high temperatures for reformer tubes (shown at bottom of photograph).

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

For more data on advertised products, use Readers' Service Cards, last page.

Men . . .

in the lube and wax area. Later he worked on an Esso Research-developed refining process.

Thomas S. Lennox, manager of Mobil Oil Co.'s Trenton, Mich., refinery since 1956, will retire June 1 after 30 years of service. He will be succeeded by **Kenneth W. Reinhardt,** manager of Mobil Oil's manufacturing employe relations since 1956. Reinhardt's successor will be **Russell B. Tompkins,** project supervisor in Socony Mobil's Employe Relations Department. Lennox received a degree in chemical engineering from the Royal Technical College and came to the United States in 1921. He joined Socony Mobil in 1930 as manager of the Grease and Compounding Department, Trenton plant. Reinhardt joined Socony Mobil in 1933, leaving one year later to enter Union College. Tompkins is a graduate of Dartmouth College and has been with the company since 1946, starting in sales.

Sidney F. Prigg, crude units area foreman at the Mobil Oil Co. refinery, Torrance, Calif., has retired after setting a record of 38 years of employment without loss of a single day's work. Company records show that no one else has ever approximated Prigg's record of never having been late or absent in over 9,500 working days. Teeth extractions and a "bad cold" accounted for the only two near misses Prigg had. "It would have been tough to do if I hadn't like my job," says Prigg.

Tear Sheets—Reprints

Handling costs compel Gulf Publishing Company to make a charge of 25 cents per article for all TEAR SHEETS ordered. Such tear sheets will be sent, when available, if cash (or company requisitions) is sent with the order.

Small, individual orders for REPRINTS of articles will carry a 50-cent charge per copy WHEN AVAILABLE. Cash (or company requisitions) must also accompany these orders. The $1. price on some of our larger reprints will, of course, continue to apply.

These price rules do not affect quantity orders (starting at 100 copies) of any article printed. Prices for these will be quoted upon request.

Address: Reprints,
Petroleum Refiner,
Box 2608
Houston 1, Texas

This Ampco Pipe has a ¾" wall, to handle sulphuric acid sludge in oil-company operation.

Sulphuric Acid Sludge No Problem

for major oil company,* in 1000-lb. transfer service

Its Ampco Pipe and Fittings resist corrosion

Ampco Pipe successfully handles problem liquids like these:

Boiling sulphuric acid (up to 50%)

Hot concentrated caustic solutions

Phosphoric and acetic acids

Phthalic anhydride

Phenols

Furfural

Brine

*Name upon request

Many other companies avoid corrosion shutdowns this same way.

Ampco Pipe is made from an exclusive aluminum-bronze alloy that . . .

(a) Resists many acids and caustics.

(b) Withstands the action of abrasive solids in suspension — resists cavitation-pitting.

(c) Has a Brinell hardness of 150 and tensiles up to 70,000 psi.

(d) Stands up under wrenches and hammers, without thread distortion and subsequent leakage.

(e) Has high velocity tolerance — flow rates of 18-20 fps.

You can get Ampco Pipe in all standard sizes, many from stock. Fittings are available to 3000 psi; flanges, to 5000 psi.

Write us concerning *your* problem.

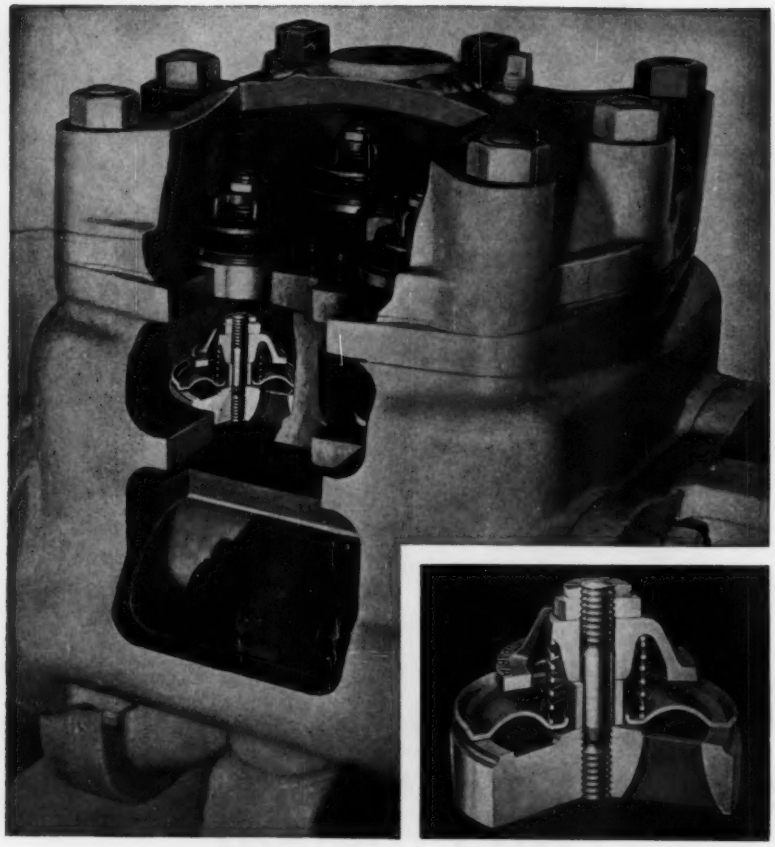
AMPCO®

AMPCO METAL, INC.

Dept. 381E, Milwaukee 46, Wis. • West Coast Plant: Burbank, Calif.

THE METAL WITHOUT AN EQUAL

For more data on advertised products, use Readers' Service Cards, last page.



The valve for reciprocating pumps . . . old or new

Because they offer a happy combination of dependability, efficiency and extra life, DURABLA Valves are a credit to any reciprocating pump. Mechanically and metallurgically speaking, they will operate freely under temperature-pressure extremes, with highly corrosive fluids and in any position.

In a DURABLA Valve Unit, only "point contact" is made by the valve member on the sleeve, so it can't bind or hang-up. Due to its unique arched design, neither will it warp. The new V-7* taper-locked stud can be screwed down tight into the seat without any possibility of galling or breakage. And a self-locking nut and "drop-on" guard assure quick and easy inspection of working parts —without stud or seat removal.

Standard equipment on many new pumps, DURABLA Valve Units are also used throughout the world to re-valve older pumps. They come in fifteen sizes, designed to meet over 300 variations in installation requirements.

Write for new booklet PR50.

DURABLA MANUFACTURING COMPANY
114 Liberty Street, New York 6, New York

DURABLA®

*Patent applied for

DM-34

Men . . .

Ford H. Blunck has been named coordinator of foreign operations for Standard Oil Co. (Indiana). Dr. Blunck's coordinating responsibilities will cover all of the foreign operations of Standard and its affiliates, other than those engaged in exploration and production. He has been in the company's Chicago general office as manager of the Planning Division, Manufacturing Department, since 1956. He joined Indiana Standard at its Whiting, Ind., Research Laboratories in 1936.

John C. Jarratt has been appointed supervisor of operations at Texaco's Eagle Point plant, Westville, N. J. He has been chief process engineer at the company's El Paso, Texas, refinery since 1957. He joined Texaco in 1950 as a chemical engineer at Port Arthur, Texas, following graduation from The University of Texas, where he received a B.S. degree in chemical engineering. He has also served at Texaco refineries in Casper, Wyo., and West Tulsa, Okla.

C. L. Cox, J. F. Barker and D. D. Roselius are new members of Technical Division, Humble Oil & Refining Co.'s Baytown, Texas, refinery. Cox holds a B.S. degree in civil engineering and Barker and Roselius B.S. degrees in chemical engineering from The University of Texas.

Dr. Jesse B. Patberg has been promoted by Esso Research and Engineering Co. to head of the Marketing Technical Section, Products Research Division. He has been in the Products Research Division since he joined the company in 1942. He spent two years in the Marketing Technical Section earlier in his career and, before returning to the section, headed a group in the automotive fuels and motor lubes sections and served as acting head of the automotive fuels section. A chemist, Dr. Patberg was awarded his doctorate from the University of Illinois, where he was a research associate while studying for his advanced degree. His bachelor's degree, also in chemistry, was earned at Evansville College in Indiana.

James R. Bowden, research group leader in Continental Oil Co.'s Research and Development Department, Ponca City, Okla., is to receive a 1960-61 Sloan Fellowship at MIT. The award is part of the Sloan Fellowship Program for Executive Development, and extends

Items of Interest to the Processing Industry

WOLVERINE TUBE

PUBLISHED BY WOLVERINE TUBE

SOUTHWEST CHEMICAL COMPANY SAVES $50,000 BY USING WOLVERINE TRUFIN® TYPE S/T

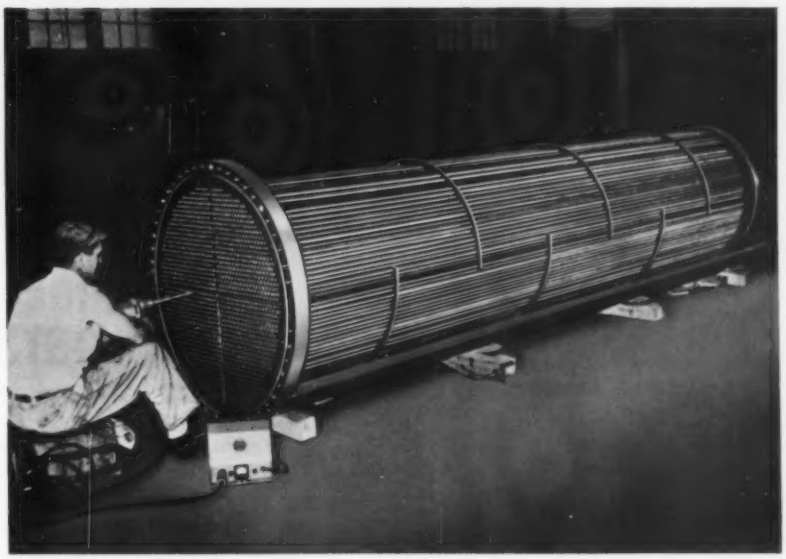
BY ERNEST DODD

Fifty thousand dollars is a lot of money . . . yet this is the amount saved by a large southwestern chemical company when it used Wolverine Trufin Type S/T condenser tubing to solve a specific heat transfer problem.

In this case, refinery engineers desired to increase the throughput of a given operation. However, a survey revealed that to get the necessary increase would require doubling the heat exchanger surface.

This would have required another heat exchanger as large as the existing unit along with additional space and structure. This naturally involved considerable money.

However, a study of the problem revealed that by redesigning the existing bundle and retubing with Wolverine Trufin Type S/T — the original, integrally finned condenser tube—the need for the additional equipment would be eliminated. This was done using Trufin Type S/T in pure nickel form. Savings in time,



labor and materials have been estimated at more than $50,000.

This is but another in the long list of authenticated examples of the outstanding heat transfer job that Wolverine Trufin Type S/T is doing throughout American industry. Why not get the complete story for yourself? Write for the Trufin Catalog or talk to one of Wolverine Tube's highly trained heat transfer sales specialists. Their names, addresses and telephone numbers are listed in the telephone directory yellow pages.

ADMIRALTY TRUFIN OFFERS 13% BOOST IN SURFACE AREA

Does your heat transfer operation require admiralty condenser tube in integrally finned form? *Then here's good news for you!*

Recent developments coming from Wolverine Tube's continuous research program, make possible a 13% increase in the outside surface area of Trufin Type S/T admiralty condenser tube.

This increase is made possible through the development of a readjusted fin contour that permits admiralty Trufin to compare favorable in outside surface area with copper Trufin Type S/T.

As a result, shell and tube units, where admiralty Trufin Type S/T is used, can gain a significant increase in outside surface area which in turn means a significant increase in total heat duty handled or a decrease in the size of the exchanger or both.

This is a point well worth remembering if you are about to retube existing units or are considering the design of new equipment.

TRUFIN TYPE S/T IDEAL FOR USE IN NEW OR OLD UNITS

Wolverine Trufin Type S/T is finding ever increasing acceptance in the chemical, petro-chemical and petroleum refining fields . . . for use both when retubing existing equipment or designing new units.

Retubing an existing heat exchanger can be accomplished, in many instances, simply by directly substituting Trufin Type S/T for prime surface tube. Because its integral fins give it greater outside surface area Trufin packs more heat transfer surface into a given space thus steps up the capacity of existing units.

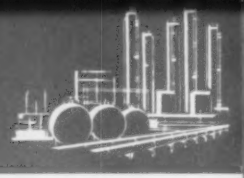
When new equipment is being designed Trufin Type S/T permits the design of smaller, more effective units with a direct saving in materials, time and labor. Trufin Type S/T is widely used in naphtha condensing, butylene condensing and lube oil cooling—is particularly effective in handling light hydrocarbons.

Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario, Canada.

WOLVERINE

TUBE

Items of Interest to the Processing Industry



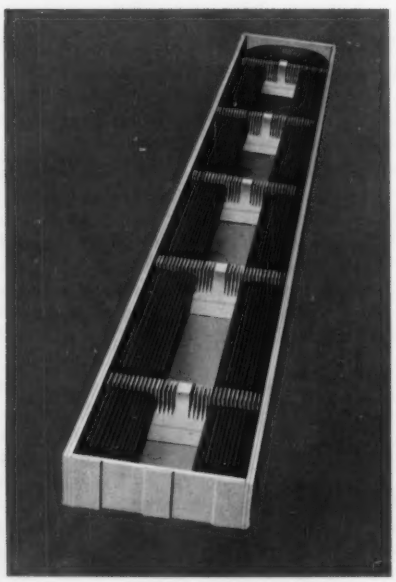
Wolverine Prefabs U-bends to your Specifications

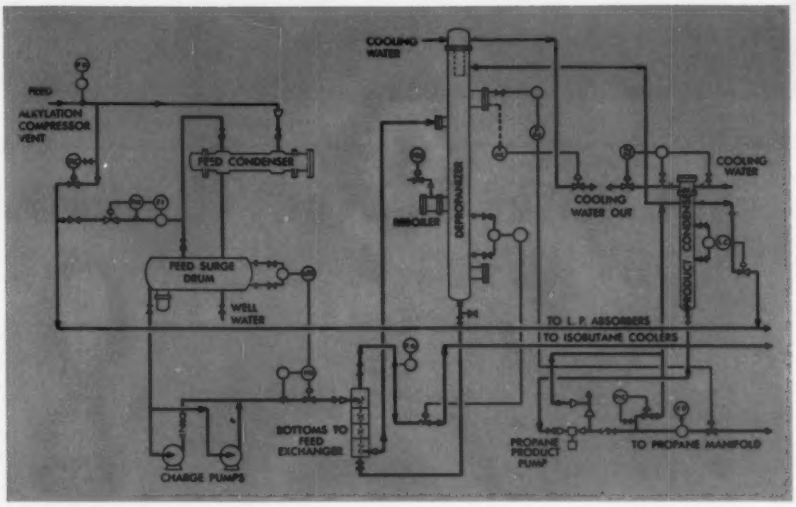
As a direct mill source Wolverine Tube prefabricates U-bend condenser tubes to your specifications — ships them in disposable type pallets in the exact order of their installation — ready for direct insertion into your heat exchanger or condenser.

In addition to real savings in assembly time, you minimize transportation, space and handling problems.

In prime surface form Wolverine U-bends are available in a wide range of sizes and alloys in copper and aluminum. Capacity boosting Wolverine Trufin U-bends (such as those used in this application) are available in copper, copper alloys, aluminum and seamless steel. Wolverine Trufin tubes can be furnished in straight lengths or bent to your specification and packaged as shown here.

Write for complete information — or have your Wolverine sales representative explain their advantages. He is as near as your telephone.





Here's How:

WOLVERINE TRUFIN® CUT COSTS IN ALKY-SYSTEM DEPROPANIZER

BY ERNEST DODD

In refining—as in all industry—using the *right* product at the *right* time can often result in savings amounting to thousands of dollars.

A recent article in a trade publication gives dramatic evidence of the value of low-fin (Wolverine Trufin) condenser tubes in the design of the above low-cost alky-system depropanizer at a large Gulf Coast refinery.

From the article: "The advantage for the internal heat exchangers, low-fin U-tube bundles, lies in the investment savings in shells, floating heads and separate foundations." — "The advantage to this design in terms of the first cost is achieved principally by locating the reboiler and the overhead condenser inside the tower.

"This was achieved by the use of finned tubes to obtain high heat input per cubic foot of tower volume. It is estimated that the savings in terms of externally located heat-exchanger shells and foundations are about $10,000. This saving is about 25 per cent of the cost of the tower itself, and 6 per cent of the total cost of the project."

The major components in the system were: (a) a feed condenser using 70° well water makeup to the reservoir as coolant; (b) a 60-foot high by 30-inch diameter tower using Spraybak cartridge packing for liquid and vapor contacting; (c) *an internal reboiler and reflux condenser;* (d) an external product condenser doubling as a product accumulator, a bottoms-to-feed exchanger and one product pump.

It was in the area of item (c) that Wolverine Trufin proved its ability as a money saver. Internal mounting was advantageous in this instance because of Wolverine Trufin's greatly increased surface area. This enabled the engineers to get more heat transfer surface into a given area thus obtaining a higher heat input per cubic foot of tower volume.

Where Wolverine Trufin is installed *savings* and *increased heat transfer performance* go hand in hand. Throughout industry authenticated cases such as that described here are becoming daily happenings.

May we suggest that you include Trufin tube in your engineering philosophy when designing heat exchangers for your use?

WOLVERINE TUBE
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Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

Men . . .

from June 1960 to June 1961. With Conoco since 1955, Bowden has B.S. and M. S. degrees in chemical engineering.

McNealy

Williams

E. W. McNealy has been appointed works manager of Texaco, Inc.'s Port Arthur, Texas, refinery. Formerly general superintendent at Port Arthur, he succeeds **Henry Flynn,** named general manager, Refining Department. **Jack C. Williams,** formerly supervisor of the department's Process and Production Division, New York, succeeds McNealy as general superintendent, Port Arthur works.

Anatole M. Schwieger, a research chemical engineer, has been named manager of European operations for Armour Research Foundation of Illinois Institute of Technology. With ARF since 1956, he left for his new post in The Hague, Netherlands, on February 21. He will direct the Foundation's European research and observation activities succeeding **Herbert B. Gausebeck.** Among Schwieger's responsibilities at his new post will be administration of the European Technical Observation Group (called ETOG) and techno-economic research in Europe.

Robert T. Kraft, formerly associated with Tennessee Gas Transmission Co. in Oklahoma City, has joined Union Carbide Corp., New York office. He attended the School of Production Technology of Kilgore, Texas, and Kent State University, where he received a degree in geology. He will be a member of the Petroleum Division, Union Carbide General Purchasing Department, specializing in procurement of natural gas for all Union Carbide divisions.

J. D. Brian has been promoted to senior coordination technician, Coordination Division, **C. W. Lubbock** to senior staff engineer, **Roger Wylie** to staff engineer, **D. L. Guthrie** to senior chemical engineer, and **T. B. Brister** to senior mechanical engineer, Technical Division, Humble Oil & Refining Co.'s Baytown, Texas, refinery.

Fred G. Crosby has been named vice president of Sun Oil Co., Ltd. In March 1959, he became a member of the board. Crosby joined Sun as a salesman in 1931.

C. W. Bates, H. T. Campbell and C. T. Jones have been promoted to senior supervising engineers in the Tech-

American 200 Series Chemical Feed Pumps

• METERING ACCURACY OF ±1%

• CAPACITY TO 1624 GPH.

New 200 Series Simplex model can pump up to 812 gph. Duplex model has double this capacity. Maximum pressure of 10,000 psi.

Easy, inexpensive operation is assured by these quality features:

- Self-contained lubrication system—no downtime for lubrication.
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- Crossheads of hardened and ground steel ride on cast iron.
- Heavy duty reducers.
- NEMA frame motors.

Precision built 200 Series pumps handle a wide variety of "tough," corrosive materials. In Chemical Processing, Refining and Boiler Feed operations, the pumps assure highest accuracy in feeding precisely metered fluids in virtually all ratios, with flow, temperature, pressure, conductivity, PH and other controlled process variables.

Write today for more information.

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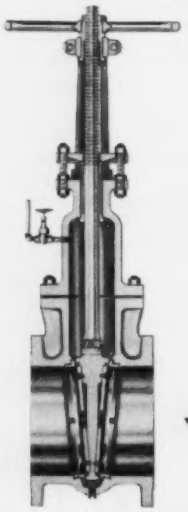
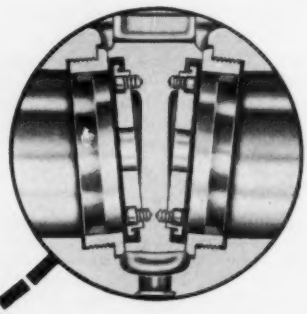
You get DUAL SEATING with Pacific's BTV-BTR Gate Valves

Pacific's dual seal BTV/BTR gate valves incorporate the effective application of BOTH metal-to-metal seal and mechanically locked-in elastomer secondary seal to effect a positive shut off in a gate valve designed to meet all petroleum and chemical service applications. For the first time, a valve manufacturer is able to utilize two elastomer-type materials, Viton* and compounded rubber, which supplement each other, to offer effective sealing over an unusually wide temperature range and resistance to a great many more corrosive materials and combination of fluids. With the unique dual seat design, seat efficiency is increased as line pressure is increased. Valve seal is not affected by change in direction of flow, by pressure differentials or by line fluctuations. Important new safety feature permits visual proof of positive seat tightness after each valve closure. This test procedure is quick, certain, and safe! Available in carbon and alloy steels. 150 lb. pressure series 1½" to 24", 300 lb. pressure series 1½" to 16". Temperature limitation −20°F. to +400°F. For additional information ask for Brochure BV-1.

*Trade mark of I. E. DuPont Company



Write for brochure



PACIFIC VALVES, INC.

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Sales offices in most principle cities.

Men . . .

nical Division, Humble Oil & Refining Co.'s Baytown, Texas, refinery. Bates is in charge of the Control Systems Engineering Section and Campbell heads one of the mechanical engineering sections. Jones is on a rotational assignment as head of the Cost and Evaluation Division, Houston office. Bates and Jones have chemical engineering degrees, and Campbell a mechanical engineering degree.

G. Gordon Biggar has been named vice president in charge of public relations for Shell Oil Co. He succeeds **H. L. Curtis,** who has retired. Curtis has been vice president since 1955. Manager of the Public Relations Department since 1952, Biggar began his oil-industry career in 1926 as a service station attendant with the New England Oil Refining Co., Boston. He joined Shell in 1929, and later served in marketing and sales promotion positions in Boston and New York. He has been in public relations since 1941.

Biggar

Jack M. Paul has been named a group leader at the Whiting Research Laboratories, Standard Oil Co. (Indiana). Since he joined Standard in 1950, he has specialized in pilot-plant development of petrochemical processes. In his new position he will head a group carrying out similar studies. Paul is a chemical engineering graduate of the University of Utah, and is a member of ACS.

Victor F. Massa has been appointed engineering associate, Products Research Division, Esso Research and Engineering Co. He joined the company more than 30 years ago after attending Newark College of Engineering. Massa's research efforts are devoted to studying combustion chamber deposits. He also has been involved in automotive fuel testing work.

James C. Reed has been named executive vice president of Procon, Inc. **Alexander G. Petkus** becomes senior vice president, coordination, engineering, and drafting; **James R. Britt,** vice president, European operations, and **Charles B. Robbins,** vice president, staff.

Drs. B. H. Johnson, F. W. Lampe and A. T. Watson have been promoted to research specialists in Humble Oil & Refining Co.'s Research and Development Division, Baytown, Texas. Dr. Johnson will specialize in fundamental investigations concerning the structure and mechanism of catalytic action of the recently discovered alkyl metal-transition metal catalysts. He will be responsible for exploratory investigations into new uses of these catalysts. Dr. Watson will spe-

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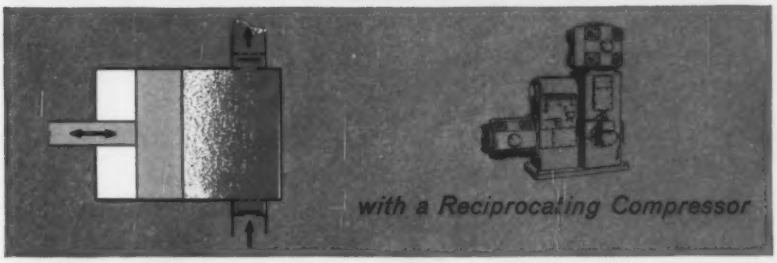
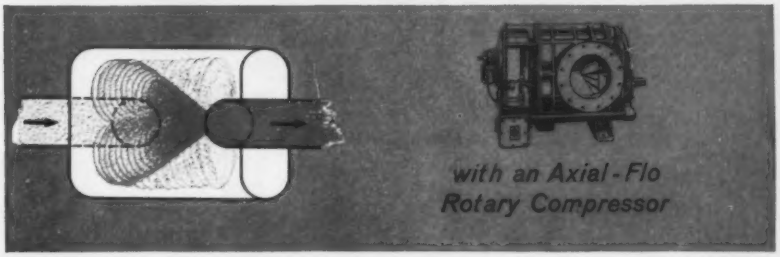
WHIRL IT

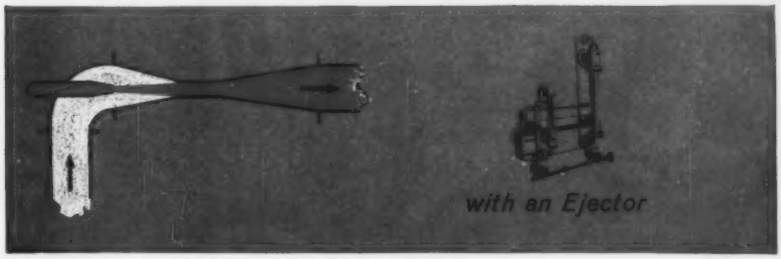
PUSH IT



SQUEEZE IT



PULL IT



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For any pressure, or gas, Ingersoll-Rand can supply whatever type of compression or evacuation system will meet your exact requirements to *best advantage*—with maximum efficiency and dependability. For completely unbiased recommendations that will save you money in the long run, be sure to call in your Ingersoll-Rand engineer the next time you have a compression problem.

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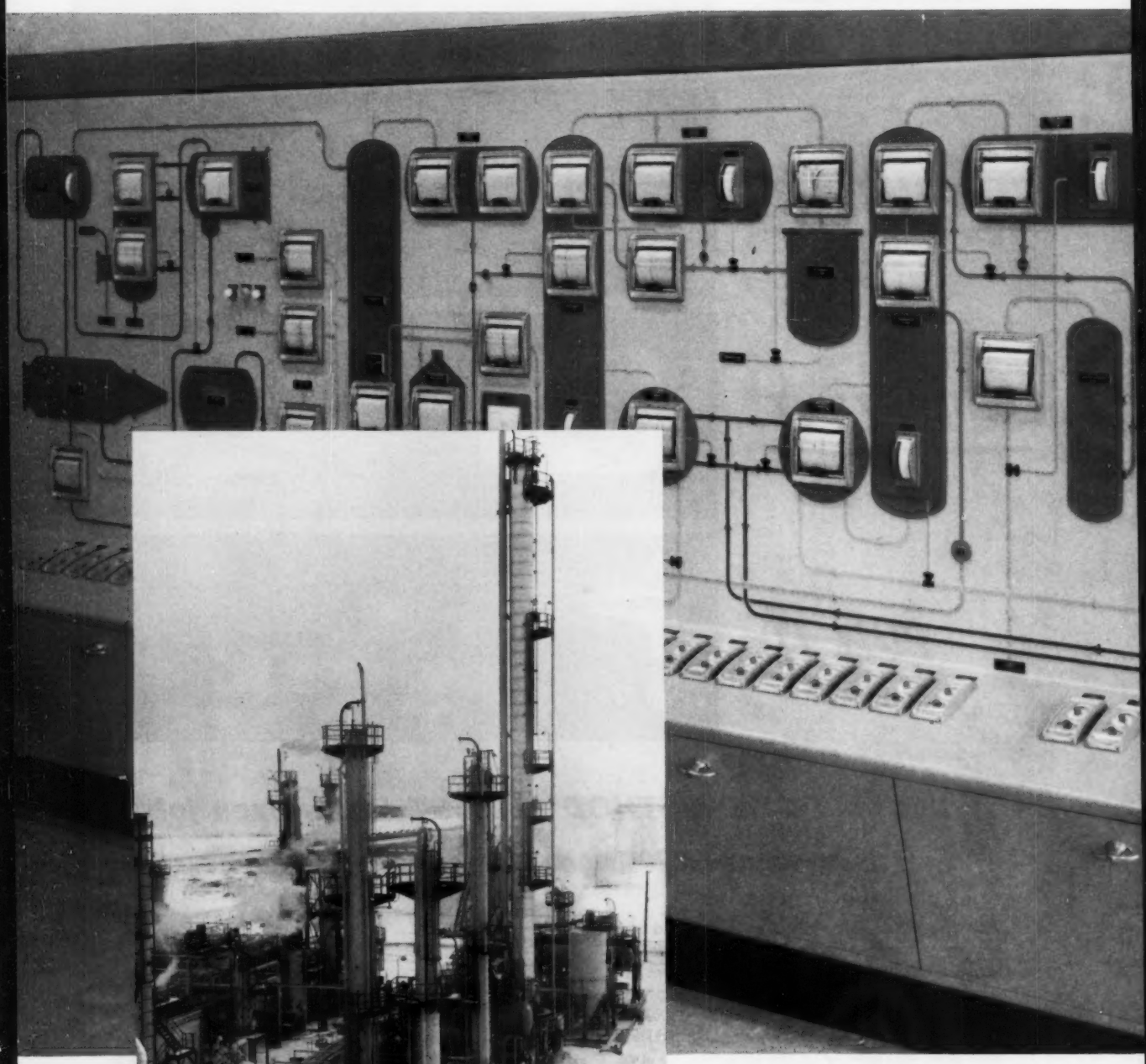
at Imperial Oil Limited

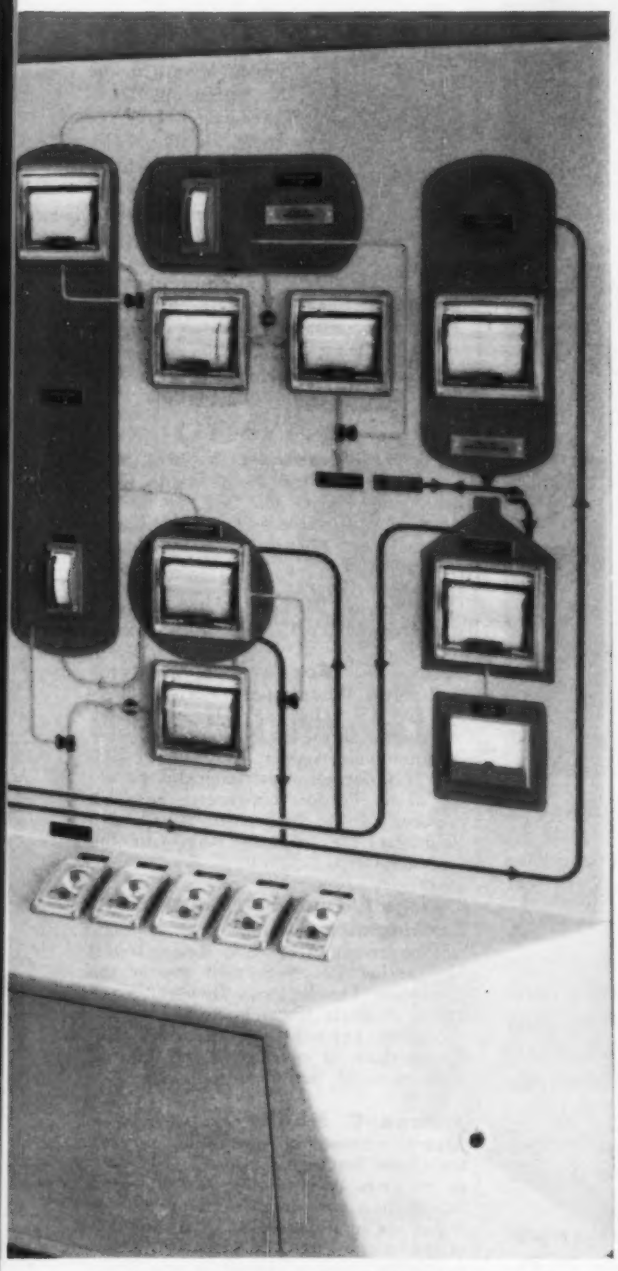
They wanted a low
they chose Foxboro



◀ New Hydrofluoric Acid Alkylation Unit at Imperial Oil Limited, Winnipeg, Manitoba. Unit was designed by the Universal Oil Products Company for Imperial Oil.

PHOTOGRAPHY BY FREDERIC ALKIER, WINNIPEG

maintenance electronic system... Electronic Consotrol instrumentation



▲ **FOXBORO ELECTRONIC CONSOTROL PANEL** at Imperial Oil includes 32 control loops. 3″ x 6″ Control Stations are so compact they are mounted on panel console, while recorders are mounted directly in the graphic diagram above.

problems of "frozen" air and vacuum tubes eliminated in new HF Alkylation Unit at Winnipeg, Manitoba

There were significant reasons for installing Foxboro Electronic Consotrol* Instrumentation on Imperial Oil's new HF Alkylation Unit in Winnipeg, Manitoba.

First — Foxboro electronics completely eliminated their problem of air supply — particularly vexing in a climate where the temperature drops below freezing 9 months out of the year.

And second — they like Foxboro's "all solid state" feature, because they'll never have an instrument failure due to a burned out vacuum tube.

Imperial Oil also appreciates the compactness of Foxboro electronic control panels. Compact 3″ x 6″ controllers are located on sloping panel console — 4-inch strip chart recorders are integrally-mounted in graphic diagram. With a minimum of searching, the operator knows how the process stands.

If speed of response, sensitivity, and reliability play an important role in your process, it will pay you to investigate Foxboro Electronic Consotrol instrumentation. Ask your Foxboro Field Engineer about it. Or write for Bulletin 21-10. The Foxboro Company, 745 Néponset Avenue, Foxboro, Massachusetts.

*Reg. U. S. Pat. Off.

FOXBORO

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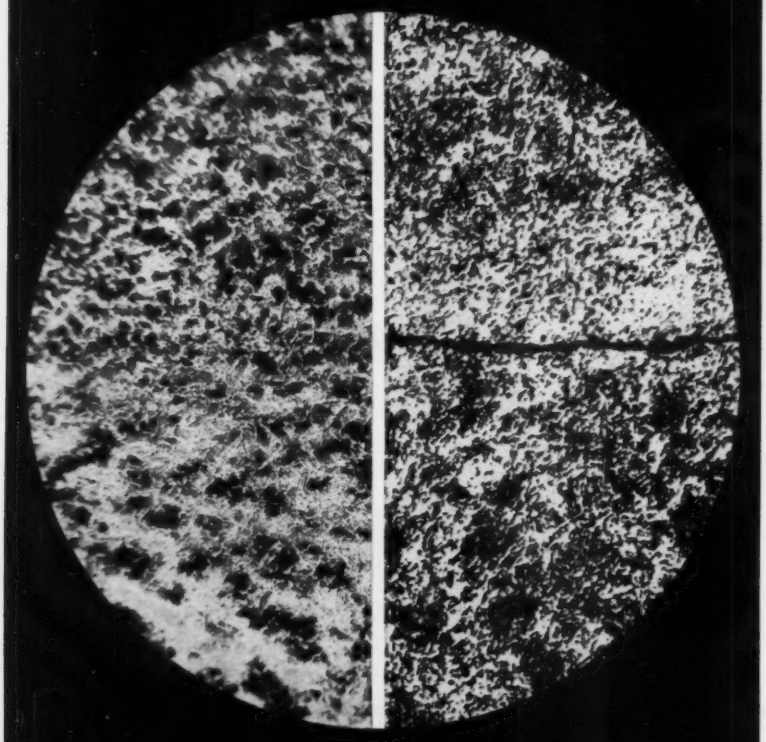
why TRU-WELD is a stronger, better grating



photomicrograph of grating welds

This enlargement of the weld area in TRU-WELD grating shows how solidly the metals have joined. Cross bar and bearing bar have fused into a strong, moisture- and vibration-proof weld.

Enlargement of an incomplete weld area. Note the line of separation between bearing bar and cross bar. Heavy traffic and vibration can easily separate such a weld.

Tru-Weld grating is stronger because it is *made* that way. Its added strength comes from a manufacturing process that completely fuses the metal at cross bar-bearing bar joints and holds the bars to exact spacing. The result is grating that stands up under excessive vibration, heavy traffic or in areas where corrosive fumes and moisture are a problem. And Dravo Tru-Weld grating *costs no more.*

Complete estimating, layout and fabricating services are available. Immediate delivery from stocks maintained at nearby Joseph T. Ryerson Service Centers will help you meet exacting construction schedules.

For more information on this new, stronger grating, call the Dravo representative in your area, or write DRAVO CORPORATION, PITTSBURGH 25, PA.

DRAVO
CORPORATION

Men . . .

cialize in fundamental studies of rheology and basic physics of polypropylene and other polymers. He will also study catalyst modifications and their effect on the basic properties of polymers produced therefrom. Dr. Lampe is on a rotational assignment as a section head in charge of the group covering exploratory and fundamental research on fuels and chemicals.

J. J. Dvorak has been promoted to assistant division head in the Technical Division, Humble Oil & Refining Co.'s Baytown, Texas, Refinery. He directs the efforts of the Central Engineering Branch. This includes groups covering civil engineering, mechanical engineering, electrical engineering, control systems engineering, project engineering, and drafting. Dvorak holds a B.S. degree in civil engineering from the Rice Institute.

Dvorak

Fred H. Ramseur, Jr., has been named manager of the Gasoline Division, Cities Service Oil Co., and elected a director. He succeeds **Frank M. Perry,** who has been elected president and general manager of Petroleum Chemicals, Inc., New Orleans. Ramseur comes to Cities Service, Bartlesville, after 18 years with Arkansas Fuel Oil Corp.

James M. Marzen has joined the staff of the Whiting Laboratories, Standard Oil Co. (Indiana). He will carry out studies on the combustion of gasoline in automobile engines. A holder of B.S. and M.S. degrees in mechanical engineering from Purdue University, he is a member of the Society of Automotive Engineers. He formerly was with the Chrysler Corp.

George F. Feldbauer and Alan R. Cunningham have been named engineering associates for Esso Research and Engineering Co. Both men are in the Petroleum Development Division. Feldbauer conducts research studies on hydrocarbon separation processes, while Cunningham is concerned with making evaluations of petroleum processes.

Wilfred C. Hugli, Jr., has been named manager of operations research for Cities Service Oil Co. He has been in research activities for 20 years, and has been a consultant to a number of major corporations. Hugli is a graduate of Stevens Institute of Technology, and before becoming a consultant was director of the Operations Research Laboratory at Stevens.

George Lewis, who has been assistant superintendent of Texaco, Inc.'s Los Angeles works, has been named superin-

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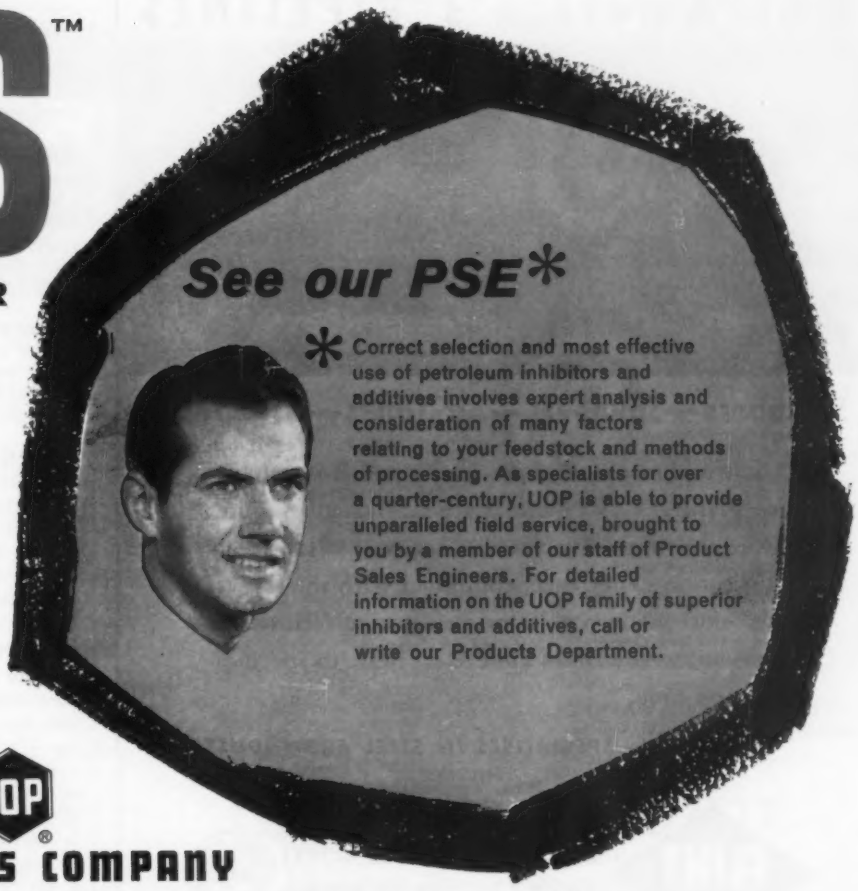
ALSO SPEEDS AIR SWEETENING...

All the desirable properties that have made UOP No. 5 the standard of phenylene diamine inhibitors for more than two decades are retained in UOP No. 5-S Inhibitor.

It is equally potent in preventing gum formation and TEL decomposition. But for stubbornly sour gasoline, No. 5-S has the edge—can bring about completion of sweetening reaction in three-quarters to one-quarter of the time.

This property is important. UOP No. 5-S sweetens gasolines other inhibitors find difficult to handle—may allow a decrease in oxygen added, lowering of temperature, or reduction in inhibitor concentration.

UOP No. 5-S™ INHIBITOR


See our PSE*
* Correct selection and most effective use of petroleum inhibitors and additives involves expert analysis and consideration of many factors relating to your feedstock and methods of processing. As specialists for over a quarter-century, UOP is able to provide unparalleled field service, brought to you by a member of our staff of Product Sales Engineers. For detailed information on the UOP family of superior inhibitors and additives, call or write our Products Department.

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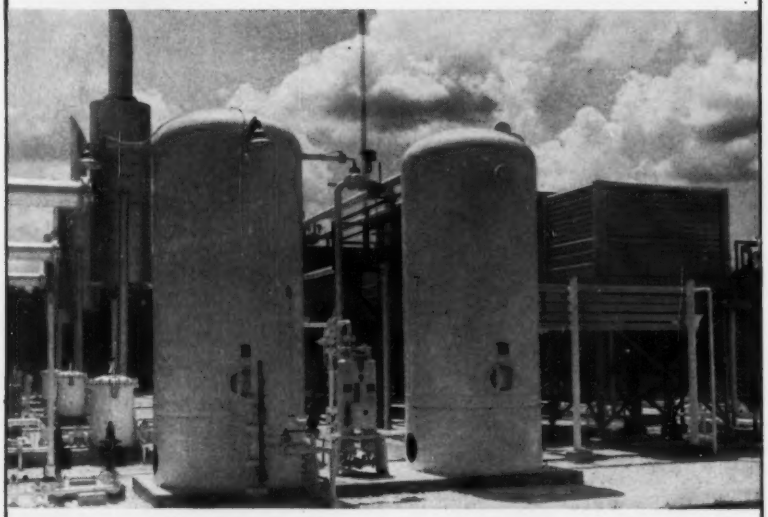
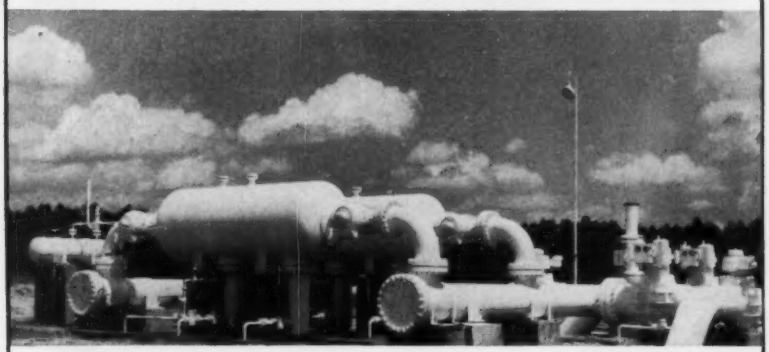
WHERE RESEARCH TODAY MEANS PROGRESS TOMORROW

FLINT STEEL

PRESSURE VESSELS



Dot America's PIPELINES



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STEEL PLATE FABRICATORS ASSOCIATION

Men . . .

tendent of the El Paso, Texas, refinery. **George Patterson,** who has been an assistant superintendent of the Port Arthur, Texas, refinery, replaces Lewis as assistant superintendent, Los Angeles.

Carroll C. Cook has been named project manager in Delhi-Taylor Oil Corp.'s Special Projects and Planning Department. Formerly assistant to **Senior Vice President Fred P. Sewell,** his new duties are in the analysis and follow-up of new project proposals.

Robert B. Costello has been named operations manager of the Buenos Aires, Argentina, office of Kellogg Pan American Corp. He will be responsible for engineering, procurement and construction activities of the company in Argentina. Costello has been with Kellogg since 1949 and before his new appointment was division engineer, construction engineering and inspection. He has had field and home-office refinery and industrial-plant construction experience, and a BME degree from Stevens Institute of Technology.

Costello

John Keselik has been named manager of the Riverside plant, The Dow Chemical Co., Pevely, Mo. He succeeds **Robert E. Reinker,** who has been appointed assistant to the operations vice president, Dow Chemical International, Ltd. S. A., Midland, Mich.

Edward L. Wiseman has been promoted by Union Oil Co. of Calif. to senior research chemist, Union Research Center, Brea, Calif. Also named senior research chemist is **Vernon E. Stiles.**

Paul O. Dunham has been named staff patent attorney, Patent Division, Esso Research and Engineering Co. He will serve as a consultant and advisor on strategy and procedures in certain patent matters. Dunham was previously a member of the Contact and Licensing Group.

Maurice E. Brooks, George R. Collins and Ralph E. Wise have been elected vice presidents of The Lummus Co. Brooks is director of engineering. He joined the company in 1940 as a process engineer and has since served as senior process engineer and manager of Lummus' French subsidiary, assistant to the vice president of engineering, manager of production engineering and director of engineering coordination. Collins is director of construction. He joined Lummus in 1935 as assistant general superintendent of construction. Since

For more data on advertised products, use Readers' Service Cards, last page.

If you're planning to build a new plant — to extend — or to rebuild . . . tap this rich stream of low-temperature experience! If it's a question of gas separation or recovery, Air Liquide has the efficient, economical, proven answer.

The Air Liquide stream of experience has been flowing around the world for over half a century. Gaining year by year broader and accurate know-how, it has produced hundreds of low-temperature gas separation plants all over the globe.

Whether you need a plant from an existing design or one especially designed for your particular requirements, Air Liquide can supply it. From the initial technical consultations, design work, manufacturing of plant and equipment, to the expert erection and start-up supervision, our widely experienced Research, Design, and Project teams smoothly coordinate with yours.

We shall be pleased to consult with you in the application of Air Liquide processes and equipment to your particular needs. Write or call us at 405 Lexington Ave., New York 17, N. Y. Telephone: YUkon 6-6544.

AIR LIQUIDE HAVE DESIGNED AND BUILT THE FOLLOWING TYPES OF PLANTS

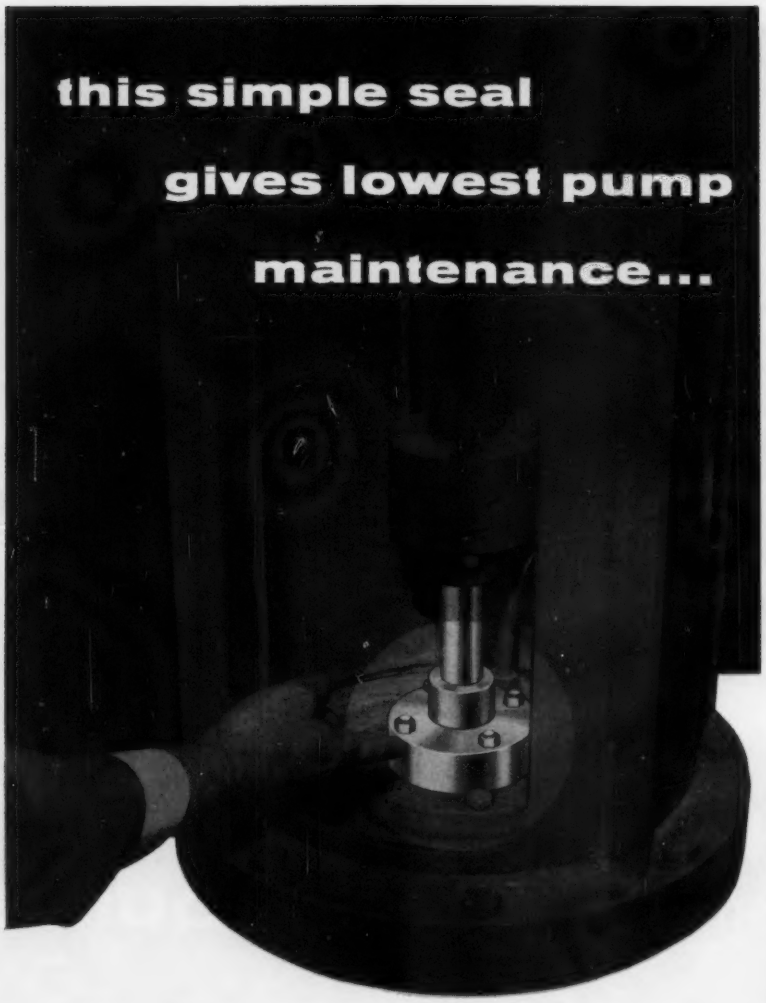
- Air Separation — oxygen, nitrogen, etc.
- Tonnage Oxygen and Nitrogen (Gas and Liquid)
- Rare Gases Recovery
- CO_2 Purification
- Methane Purification
- Natural Gas Liquefaction
- Coke-Oven Gas Separation
- Refinery Gas Separation
- Hydrogen Liquefaction
- Helium Recovery
- Pure CO_2 Production
- Heavy Water for Atomic Reactors

IN CANADA:
L'Air Liquide,
1210 Sherbrooke St. W.,
Montreal, Quebec,
Telephone: VIctor 2-5431

AMERICAN
AIR LIQUIDE
ENGINEERING & CONSTRUCTION DIVISION
OLDEST IN EXPERIENCE — NEWEST IN DESIGN

405 LEXINGTON AVE., NEW YORK 17, N.Y.

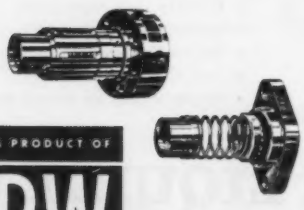
For more data on advertised products, use Readers' Service Cards, last page.



Save up to 66% of the time—expensive downtime—needed for installation or service of other mechanical seals used in plant process equipment.

The simple, effective Borg-Warner Type U Seal has no set screws—no close spring tension adjustments. It's fast and reliable.

For plants with a wide variety of pump service requirements, a minimum inventory of parts, and an easy change of gaskets adapts the Type U seal for service at temperatures of from —100 below zero to +650°F, and for pressures from 0 to 1000 psi.



Backed by Borg-Warner and proved in service, these dependable seals give complete safety, even in unattended stations.

Send for the latest Type U Seal engineering information—there's no obligation.

A PRODUCT OF B-W BORG-WARNER

Borg-Warner Mechanical Seals

P.O. Box 2017, Terminal Annex, Los Angeles 54, Calif.

Men . . .

then he has served as construction superintendent, and manager of construction, New York office. Wise joined Lummus in 1945 as a development engineer. He subsequently was sales and process engineer, assistant sales manager-Europe, manager of Lummus' French and Dutch subsidiaries, and European coordinator. In 1959 he was elected vice president of The Lummus Co. Canada Ltd.

Alexander Kidd has been elected president of Girdler Construction Corp. He succeeds **W. Robert Wood,** who has resigned to devote full time to his duties as a vice president of Chemetron Corp. Kidd was formerly vice president of Stewart-Warner Corp., Chicago, and before that was a vice president of the M. W. Kellogg Co., New York. Wood was president of Girdler Construction since its formation last October as a subsidiary of Chemical and Industrial Corp., Cincinnati.

Kidd

Hal M. Hart has been appointed a project director at Whiting Laboratories, Standard Oil Co. (Indiana). He will be responsible for developing new ways to use electronic computers in controlling selected processes for refining petroleum. Since he joined Standard in 1940, Hart has worked in supervising technical service to refining operations. Most recently he was assistant superintendent of technical service, Whiting.

Harry B. Nason has been named staff assistant to the president of SunOlin Chemical Co. and **Nicholas A. Collora** has been named mechanical engineering assistant to **Richard D. Burt,** who is in charge of engineering planning. Nason formerly was a personnel assistant in industrial relations at Sun Oil Co., and Collora was a project mechanical engineer at Olin Mathieson Chemical Co.

Frank A. Leisey has been named a senior project supervisor at the Whiting Research Laboratories, Standard Oil Co. (Indiana). He will carry out work in designing and developing instruments for analyzing petroleum products in the refinery. Leisey has a B.S. degree in chemistry from Case Institute of Technology and M.S. degree in chemistry from New York University. He is a member of ACS.

Howard Wilson has been named supervisor of the Process and Production Division, Texaco, Inc., Houston. He was formerly assistant superintendent of the company's Eagle Point works, Westville, N. J. **Robert R. Dimock,** formerly supervisor of operations, Eagle Point works, succeeds Wilson as assistant superintendent there. **Herbert C. Tenny,**

For more data on advertised products, use Readers' Service Cards, last page.

Babbitt *Adjustable* **SPROCKET RIM**
with Chain Guide
CHANGES THAT DANGER ZONE TO A SAFETY ZONE

The distance between the floor of your plant and your overhead valves is a DANGER ZONE when piled up boxes or even ladders are used to reach the valves.
Turn it into a SAFETY ZONE — equip your overhead valves with Babbitt Adjustable Sprocket Rims with Chain Guides.

- They simplify pipe layout.
- They fit any size valve wheel.
- They are easy to install and operate.
- They operate any valve from the floor.
- They save time and money.
- The first cost is the only cost (no maintenance).
- They are packed completely assembled (one to a carton), with easy-to-follow instructions.
- A hot-galvanized rust proof chain is available for all sizes.

Babbitt Adjustable Sprocket Rims with Chain Guide are carried in stock by most mill supply houses. If your supplier does not carry them, contact us direct.

Babbitt STEAM SPECIALTY CO.
6 BABBITT SQUARE, NEW BEDFORD, MASS., U.S.A.

SPLIT-EYELET CONNECTORS

For faster, easier connection of spray nozzles, branch lines and equipment to piping and tubing carrying liquids, gases or air up to 250 psi. Write for Bulletin 93.

FOR BETTER PERFORMANCE

SPRAY NOZZLE ACCESSORIES

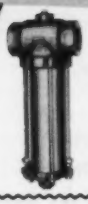
ADJUSTABLE JOINTS

For easy, exact adjustment of spray direction. Made in size for ¼" to 2½" pipe in brass, steel and stainless steel. Write for Bulletin 97.

. . . EASIER INSTALLATION

LINE STRAINERS

Special non-collapsing screen design for pressures up to 125 psi, for all pipe lines from ¼" to 6" size. Also high pressure strainers for up to 5,000 psi service. Write for Bulletin 94.



FOR COMPLETE SPRAY NOZZLE INFORMATION WRITE FOR CATALOG 24

SPRAYING SYSTEMS CO.
3283 RANDOLPH STREET • BELLWOOD, ILL.

2 New RIDGID Tubing Cutters

Give you Grooved Rollers for close flare cut-offs... no waste! Also, Enclosed Feed Mechanism • Spare Cutter Wheel in Handle •

RIDGID No. 205 Tubing Cutter
Time-Saving, Slide-to-Size ⅛" to 2⅜" O.D. Capacity

Made of lightweight, high-strength cast aluminum alloy, you'll find these new RIDGID Tubing Cutters extra handy. Slight push on handle of large-size-range RIDGID No. 205 snugs cutter wheel against tubing . . . locks it in position until released. Feed screw fully protected and enclosed . . always feeds into tube with easy handle turn . . . can't jam with chips or dirt. Wheel gives quick, clean cuts of copper, brass, aluminum tubing and thin-wall conduit . . . no burr. Grooved rollers give easy flare cut-offs without tubing waste. Tubing always turns freely on 2 of 4 Rollers. Rollers smooth tubing ready for soldering. Fold-in reamer always handy. Spare Cutter wheel in handle. Wheel for plastic and aluminum pipe available for No. 205 only.

Conform to Fed. Spec. GGG-C-771b Type II—Class I—enclosed feed mechanism

RIDGID No. 105 Tubing Cutter

Protected Feed Screw
Always Easy-Turning
⅛" to 1⅛" O.D. Capacity

To save time and tubing, order these new RIDGID Tubing Cutters today! Your Supply House has them!

RIDGID
The Ridge Tool Company • Elyria, Ohio, U.S.A.

For more data on advertised products, use Readers' Service Cards, last page

ANNOUNCING A NEW CORPORATE NAME

for The Garlock Packing Company

Garlock Inc. becomes the new name for The Garlock Packing Company, Palmyra, N. Y., to reflect more accurately its broad diversification of products and markets.

Originally established to manufacture mechanical packings, Garlock now produces over 2,000 different styles of packings, gaskets, seals, molded and extruded rubber and plastic products for every major industry.

The new corporate name, Garlock Inc., more closely identifies this 73-year-old company with the growth and development of its product lines. *Today, industry goes to Garlock for such widely diversified products as:*

- Hydraulic-Pneumatic Packings
- Oil and Grease Seals
- Gasketing and Expansion Joints
- Braided Packings
- Molded and Extruded Rubber Parts
- Plastic Stock Shapes and Fabricated Parts
- Mechanical Seals for Rotating Shafts
- Metal Packings
- Leather Packings
- Electronic Components
- Dry Bearing Materials
- Fluorocarbon Tank Linings
- Missile and Rocket Components

To help you in selecting or applying these products, Garlock offers the services of over 126 thoroughly-trained sales engineers, 175 electronic component manufacturers' representatives, 180 authorized bearing distributors and 69 foreign distributors. Conveniently located warehouses and stocking points assure Garlock customers of prompt delivery.

At Garlock Inc., design and development of new or improved products and materials is an ever-present objective. To this end Garlock maintains extensive research and laboratory-test facilities. In addition, Garlock engineers and chemists are always ready to work with you in seeking solutions to tough application problems.

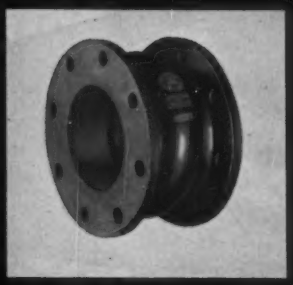
GARLOCK

To find out more about "the new Garlock," call the nearest of our 26 sales offices, or write to Garlock Inc., Palmyra, N. Y. *To assure prompt attention,* please refer to *Garlock Inc.* on all future correspondence and orders.

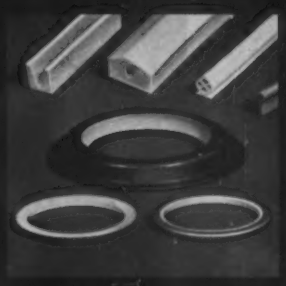
Canadian Div.: Garlock of Canada Ltd.

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

Hydraulic-Pneumatic Packings

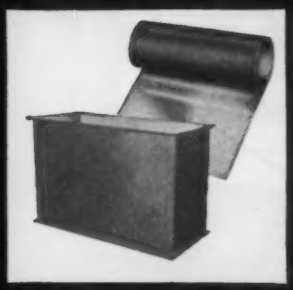


Expansion Joints



Molded and Extruded Rubber Parts

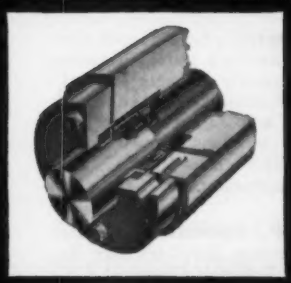
Plastic Stock Shapes
and Fabricated Parts



Fluorocarbon Tank Linings

Oil and Grease Seals

Braided Packings

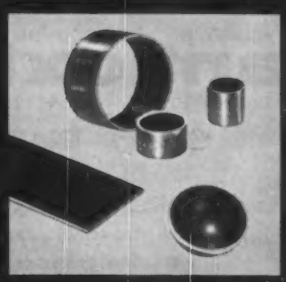


Mechanical Shaft Seals

Metal Packings

Gasketing

Spiral Wound Gaskets



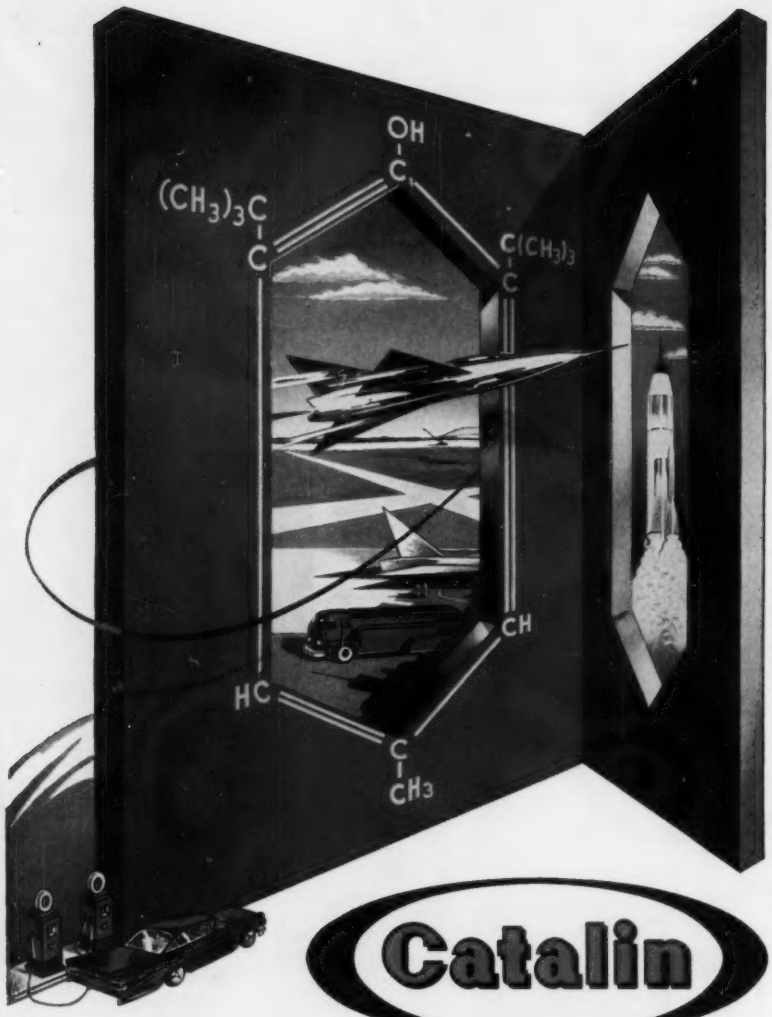
Dry Bearing Material

INC.

Missile and Rocket Components

Leather Packings

Electronic Components



Catalin

antioxidant CAO-1

98.9% PURE* sets the highest standards for purity and effectiveness

Catalin ANTIOXIDANT CAO-1 . . . the field's finest grade of 2,6-ditertiary-butyl-para-cresol . . . meets U. S. Government military specifications for use in aviation gasolines, turbine and jet fuels. A major advantage achieved with this heat-resistant, water-insoluble antioxidant is that high-octane fuels are effectively protected, with no loss of octane rating. Gum and peroxide formations are inhibited, and deposits in the aircraft intake manifold and engine are markedly reduced.

Catalin ANTIOXIDANT CAO-1 stabilizes high-octane automotive gasolines, as well as turbine, insulating, hydraulic and transformer oils . . . in fact, nearly any petroleum hydrocarbon exposed to oxidizing conditions.

Samples, literature and technical assistance wait upon your request. Inquiries invited.

Catalin Corporation of America
One Park Avenue, New York 16, N. Y.

chemicals plastics resins

* *Typical Analysis*

Men . . .

who was supervisor of the crude still area at Los Angeles works, has been transferred to Eagle Point works as supervisor of operations.

J. S. Detweiler has been appointed Oils Planning Division manager for the Manufacturing Department, Standard Oil Co. of Calif., Western Operations, Inc. He replaces **F. R. Marshall,** who is retiring. Detweiler joined Standard in 1934 in the Research and Development Division.

Philip E. Darling, director of professional recruiting for American Oil Co. since 1958, has been transferred to the parent company's Whiting refinery as head engineer, coordinating. A graduate of MIT, Darling came to the Texas City refinery in 1934, as foreman in the Instrument Department. After a series of promotions, he became chief refinery engineer in 1946. He held that position until he was named director of professional recruiting in 1958.

Darling

H. Frank Brown has been named manager of Shell Oil Co.'s Public Relations Department. Formerly manager of Shell's Visual Aids Division, he succeeds **G. Gordon Biggar,** who becomes vice president of public relations. Brown joined Shell in 1931 at Syracuse, N. Y., as a service station attendant.

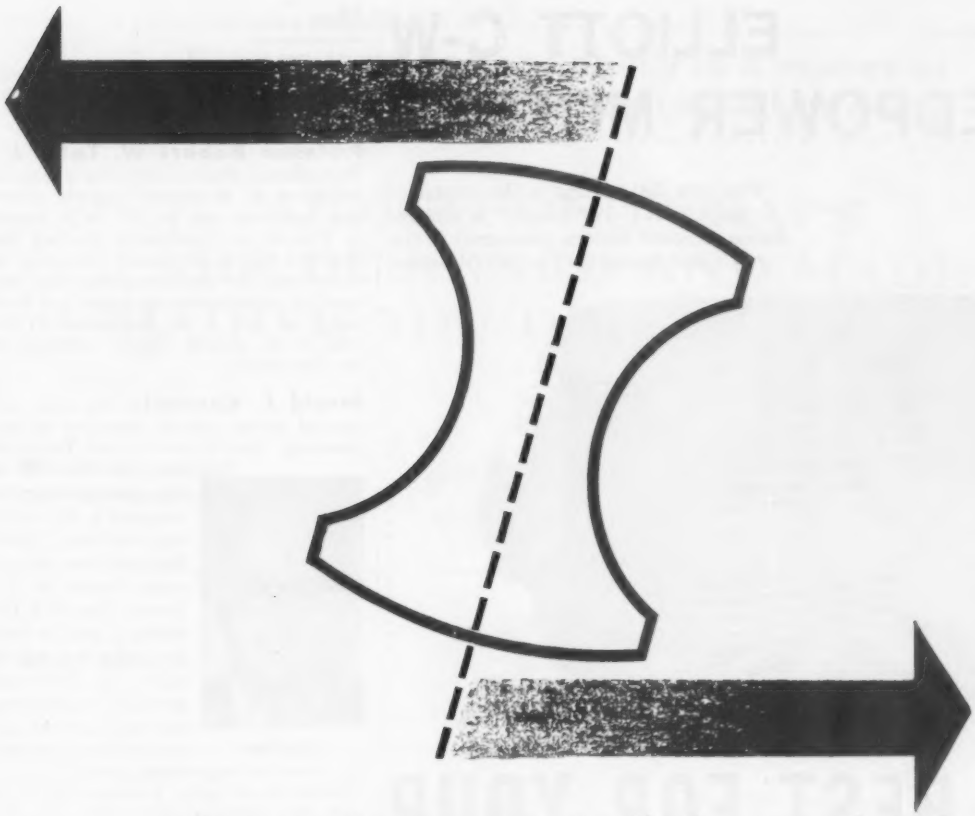
Dr. George P. Speranza has been appointed supervisor, Exploratory Research Section, Jefferson Chemical Co.'s Austin, Texas, laboratories. He is a graduate of Southern Methodist University and the University of Illinois.

E. D. Brockett and I. G. Davis have been elected to the board of Warren Petroleum International Corp. Brockett is executive vice president of Gulf Oil Corp., a member of its board, and the Executive Committee. Davis is senior vice president of Gulf.

Harris Bateman has been named a vice president of Cities Service Oil Co. He has spent 33 years with Cities Service in the fields of engineering and purchasing. Bateman is manager of engineering and purchasing and coordinator between Bartlesville headquarters and the company's Marketing Division, Chicago.

Clarence A. Christ has been promoted to senior design engineer (coordinator), Plant Engineering Department, American Oil Co.'s Texas City refinery. He graduated from Texas A & M College in 1951 with a B.S. degree in mechanical engineering. After army service, he joined American Oil at Texas City as

For more data on advertised products, use Readers' Service Cards, last page.



An assignment in "give and take"... for Lukens Application Research.

Researching the steel that best fits the job is a matter you can safely trust to Lukens Application Engineers . . . whether your problem is metal expansivity, cryogenics, abrasion, structural stress or the complexities of corrosion. A recent and typical assignment was to determine the most efficient material on which to cradle the bearing members of a bridge. These mechanisms provide the "give" that keeps a bridge structurally sound. Since corrosion-resistance was a major goal, stainless steel seemed well-suited—but costly. Lukens, with its broad fund of practical metallurgical knowledge, suggested—then thoroughly tested—the less expensive stainless-*clad* steel. The success of this engineered combination of clad and backing steel has since been borne out by a host of clad steel bearing plate applications.

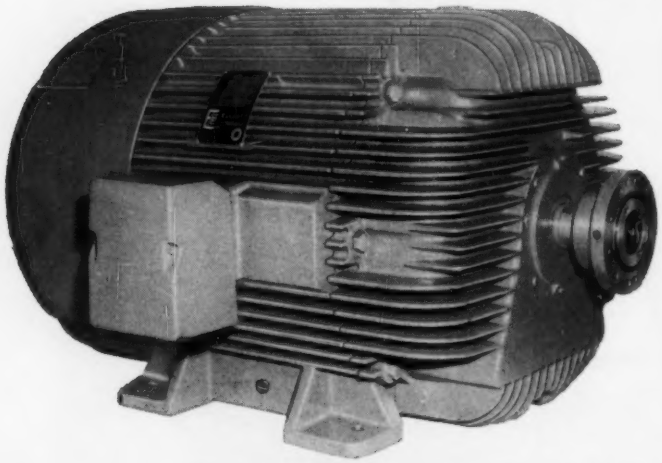
If you have an assignment in metals application, let it be our assignment too. Write Manager, Application Engineering, Services Building, Lukens Steel Company, Coatesville, Pennsylvania. Also contact us for Bridge Bearing Plate Bulletin No. S-50.

HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB

For more data on advertised products, use Readers' Service Cards, last page.

ELLIOTT C-W SEALEDPOWER MOTORS

This new 300-hp unit is the largest of the Elliott C-W "family" of ribbed-frame enclosed motors, pioneered in the United States by Crocker-Wheeler.



BEST FOR YOUR TOUGHEST JOBS BECAUSE THEY ARE BETTER COOLED BETTER PROTECTED BETTER BUILT

IMPORTANT FACTS are given in new Elliott Bulletin PB 6000-2. Send for free copy now.

ELLIOTT Company

W9-5 Crocker-Wheeler Plant • Jeannette, Pa.

Men . . .

junior construction and maintenance engineer in 1953. He became design engineer (coordinator) in 1958.

Professor Robert W. Taft, Jr., Pennsylvania State University, a key investigator in theoretical organic chemistry, received the $1,000 ACS Award in Petroleum Chemistry during the Society's recent national meeting in Cleveland. The medalist is cited for outstanding contributions to petroleum technology as well as the application to this field of the general organic concepts he has developed.

Arnold F. Kaulakis has been appointed acting general manager of engineering, Esso Research and Engineering Co. He will be responsible for the company's 800-man engineering force. Kaulakis was previously director of the Process Research Division, a post he held for almost three years. He directed activities centering on new uses for oil, hydrocarbon chemistry, chemical engineering principles, and combustion of fuels. Kaulakis has been with the company since 1942. He has a B.S. degree in chemical engineering from MIT.

Kaulakis

J. Stewart Campbell has been appointed special projects manager for research and development activities related to the nytril fiber recently acquired by Celanese Corp. of America from B. F. Goodrich Co. He will be responsible for coordinating pilot plant work at the Goodrich Development Center, Avon Lake, Ohio.

William S. Nordburg, Jr., has been named director of overseas projects, Amoco Chemicals Corp. He will be responsible for evaluating opportunities overseas for various chemical activities and for developing commercial ventures. Nordburg had been director of licensing—Research and Development Department, Standard Oil Co. (Indiana).

Roger M. Haynes has been promoted to mechanical superintendent of Continental Oil Co.'s Lake Charles refinery. Formerly mechanical superintendent at Billings, he succeeds **E. K. Dewey, Jr.,** who has transferred to Ponca City, Okla., as general maintenance engineer in the company's Headquarters Manufacturing Department.

William L. Sheets, vice president of Stone & Webster Engineering Corp. has been named senior construction manager. He will be responsible for the administrative direction of all construction department activities. Sheets joined S&W as an instrumentman in 1929 and successively worked as resident engineer,

Steam trap dependability is a matter of what the manufacturer puts into the trap

ARMSTRONG TRAPS ARE DESIGNED AND MADE TO GIVE YOU DEPENDABILITY

1. Efficient, proved operating principle

Armstrong Traps provide the most advanced development of the time-proven inverted bucket principle. Simple, but effective, there isn't much that can go wrong.

2. Good design

Armstrong Trap design gives big capacity in a small package. The mechanism is virtually fool-proof. All body styles are easy to inspect and maintain without removal from the line.

3. Highest quality materials of construction

Only the best goes into Armstrong Traps. Bodies are close grained 30,000 tensile iron castings or high quality forgings. Working parts are all tough, corrosion resistant stainless steel.

4. Good workmanship

Armstrong Traps are made by craftsmen who take pride in their work. Careful inspection and frequent checking insure the quality of the trap.

5. Application know-how

Your problem has probably been solved already in the extensive experience of the Armstrong engineering and sales organization. You can be sure of sound, dependable recommendations.

Your local Armstrong Representative can show you what Armstrong dependability can do for you. Call him today or write direct.

860 Series for low pressure heating service.

800 Series, side inlet, side outlet.

No. 801, side inlet, bottom outlet.

880 Series, integral strainer.

200 Series, bottom inlet, top outlet.

Forged Steel Series for high pressures, high temperatures.

The 48 page Armstrong Steam Trap Book tells how to correctly size, install and maintain steam traps for any pressure, any temperature, any load plus full catalog data on Armstrong Steam Traps. Ask for Catalog K.

ARMSTRONG MACHINE WORKS

8523 Maple Street Three Rivers, Michigan

For more data on advertised products, use Readers' Service Cards, last page.

Make speedier checks of recorders, controllers and base or noble metal thermocouples in industrial plants with the new three-dial 8686 Portable Millivolt Potentiometer. Features such as a central reading window . . . where measured values appear as a row of digits with a scale interpolation . . . simplify calibration of thermocouples and test measurements. The 8686 Potentiometer has: a wide operating range of −10.0 to +100.1 mv and +1010 to +1020 mv for standard cell calibration; and a high accuracy of ±(0.05% of reading +3μv) without reference junction compensation, ±(0.05% of reading + 6 μv) with ref. jct. comp. Write for Data Sheet E-33(1A).

8686 Millivolt Potentiometer

8690 Millivolt Potentiometer

Fast, accurate in-plant checking of thermocouples, recorders and controllers is expedited by the new 8690 Portable Millivolt Potentiometer. Design features such as "In-line Readout", which permit measured values to be read in digits with a scale interpolation, accelerate temperature measurements. The 8690 provides a wide range of −11.0 to +101.0 mv which eliminates input reversals; an accuracy of ±(0.05% of reading + 20 μv) without reference junction compensation, ±(0.05% of reading + 40 μv) with ref. jct. comp. Write for Data Sheet E-33(1B).

4 time-saving instruments from the

NEW

CONVENIENCE-STYLED L&N LINE . . .

8692 and 8693 Temperature Potentiometers

If you want to make a variety of temperature measurments quickly with one flexible instrument, investigate the new time-saving 8692 Single-Range or 8693 Double-Range Temperature Potentiometers. Available in any of 24 interchangeable temperature and millivolt ranges, these instruments read directly in degrees F or C on a scale 27½" long. Convenience features include: simplified range changes . . . only a screwdriver is needed to change a circuit panel, scale and binding post studs; automatic reference junction compensation . . . reference coil, built into circuit panel, compensates for thermocouple being used; accuracy . . . ±0.2% of range. Write for Data Sheet ND42-33(1A).

Need a fast-operating, high-sensitivity, high-quality null indicator for use in research, testing and production checking? Here's a new 9834 Guarded D-C Null Detector having a short period of less than two seconds for source resistances up to 1000 ohms, increasing to 4 seconds at 100,000 ohms . . . ideal for measurements with guarded or unguarded potentiometers and bridges. Of rugged construction, this portable, line-operated detector provides numerous convenience features which include four degrees of sensitivity, with a basic sensitivity of 0.2 μv/mm (0.3 μv/scale div.), and a noise level of less than ±0.1 μv. Write for Data Sheet ED7(2).

9834 Guarded D-C Null Detector

LEEDS NORTHRUP

4923 Stenton Ave., Philadelphia 44, Pa.

Men . . .

project engineer, and general superintendent on construction projects in various parts of the U. S. He was named construction manager in 1955 and elected a vice president in 1958. Sheets attended the University of Nebraska.

Dr. Paul S. Stutsman, Texas-U. S. Chemical Co.'s assistant to the president, has been promoted to manager of butadiene operations. He was transferred from Texaco, Inc., in December 1954, to Texas-U. S. Chemical, the date the new company was incorporated. He is a graduate of the University of Illinois and received his Ph.D. degree in chemistry from the University of Wisconsin in 1938.

Raymond C. Foster and Robert H. Willis have been named vice presidents of Stone & Webster, Inc. Both had been assistant vice presidents since May 1959, at which time they were transferred from subsidiaries. Foster came from Stone & Webster Engineering Corp. where he was in engineering sales work, and Willis from Stone & Webster Service Corp. where he was assistant to the president.

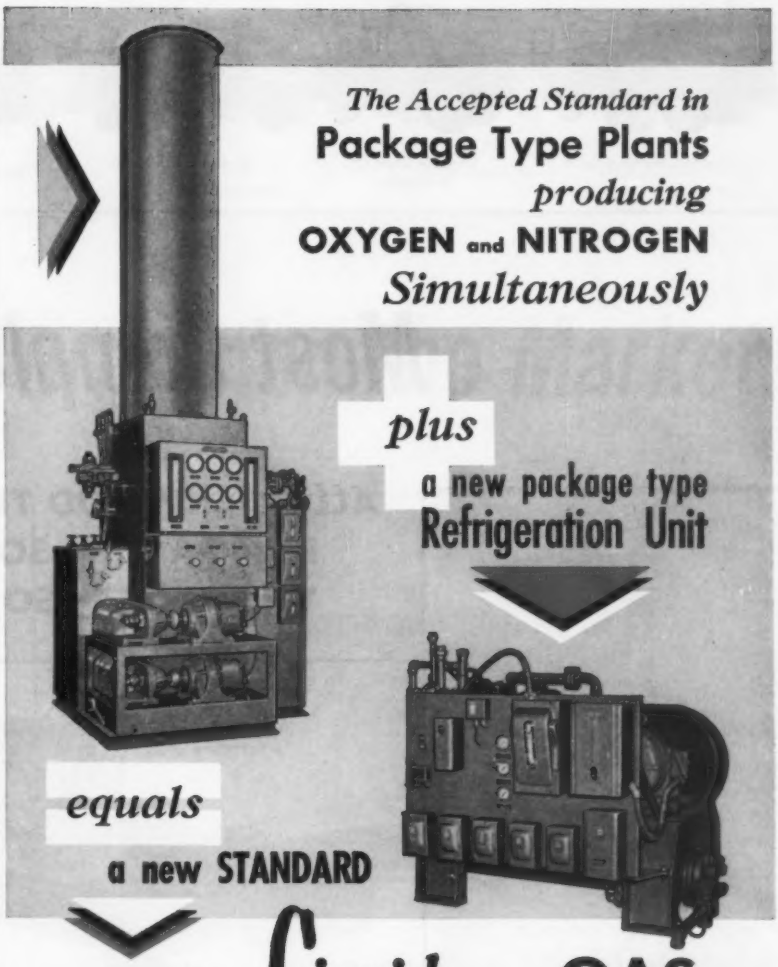
Walter A. Anderson, resident manager of Procon (Canada) Ltd., has been elected a vice president of the company. He joined Universal Oil Products Company, parent company of Procon, in 1934. He was transferred to Procon as chief estimator in 1953 and was appointed resident manager of the Canadian company in 1955.

Homer V. Flemming has been named manager of The Ralph M. Parsons Co.'s Houston office. He will be responsible for business development in the petroleum, chemical and petrochemical industries throughout the Southwestern region. Before joining Parsons, Flemming was vice president in charge of sales for The Refinery Engineering Co., Tulsa.

— Deaths —

Gerald L. Eaton, 53, former director of research and development for United Engineers & Constructors Inc., died in Philadelphia March 22 after a long illness. He was a graduate of Acadia University, Nova Scotia, and MIT. Eaton worked in the development of new processes for oil cracking and gas polymerization at the Atlantic Refining Co., from 1929-35. In 1935 he joined Gulf Oil Corp., and in 1944 became associated with United Engineers & Constructors. He was made director of research and development in 1956.

William B. Klaus, 58, Tidewater Oil Co.'s fire protection head, died Sunday, April 10, in Los Angeles. He headed Tidewater's fire-protection program in the West for many years, and previously was fire chief and assistant safety engineer at the Avon refinery. Klaus joined Tidewater in 1922.



now Liquid or GAS
OXYGEN and NITROGEN
simultaneously

FLEXIBILITY of operation, providing ANY COMBINATION of products, liquid or high pressure gas PLUS simultaneous production of BOTH oxygen and nitrogen delivers maximum yield of combined products at minimum cost of operation with little operator's attention. Packaged design requires minimum of installation cost and space.

This most modern and efficient design from Independent combines the best features of the earlier two-product package plants pioneered by Independent with the latest concepts of external refrigeration. Type illustrated in 1500 to 5500 cu. ft. per hour capacities. Other types in larger and smaller sizes. Pure argon available on larger sizes.

We invite your Inquiry

INDEPENDENT ENGINEERING COMPANY, Inc.
Manufacturers of
CONSULTING IECO DESIGNING
RESEARCH
CYLINDERS AND GAS PRODUCING EQUIPMENT
ACETYLENE · OXYGEN · NITROGEN · ARGON
O'FALLON 6, ILLINOIS

For more data on advertised products, use Readers' Service Cards, last page.

Glenn L. Martin Airport

Crucible Steel Co. of America

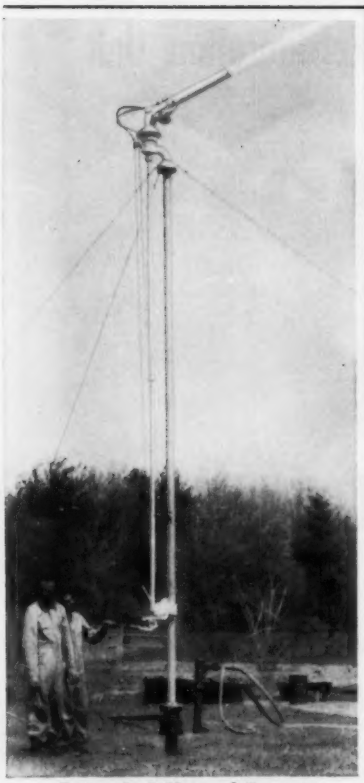
McDonnell Aircraft

Seattle-Tacoma Airport

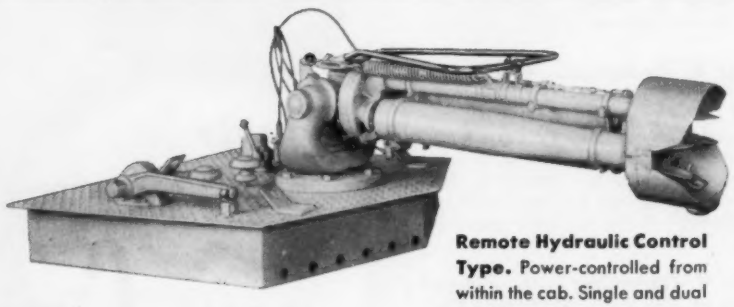
U. S. Coast Guard

Most Complete Line of

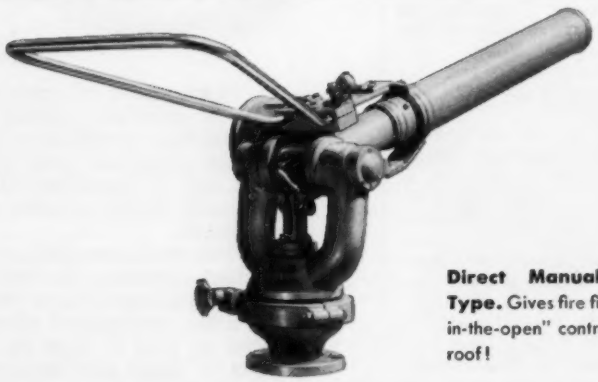
ALL ROCKWOOD TURRETS DISCHARGE
FogFOAM • SOLID FOAM STREAM
WaterFOG • SOLID WATER STREAM



Extended Manual Remote Control Type. Turret nozzles extend 10 to 20 feet above remote control station on deck or ground on standard units... greater remote extensions for special applications.



Remote Hydraulic Control Type. Power-controlled from within the cab. Single and dual models. Widely used on air crash rescue fire-fighting trucks.



Direct Manual Control Type. Gives fire fighters "out-in-the-open" control from cab roof!

Washington, D. C. National Airport

U. S. Air Force Type 0-12

Theodore Francis Greene Airport

Douglas Aircraft Co.

For more data on advertised products, use Readers' Service Cards, last page.

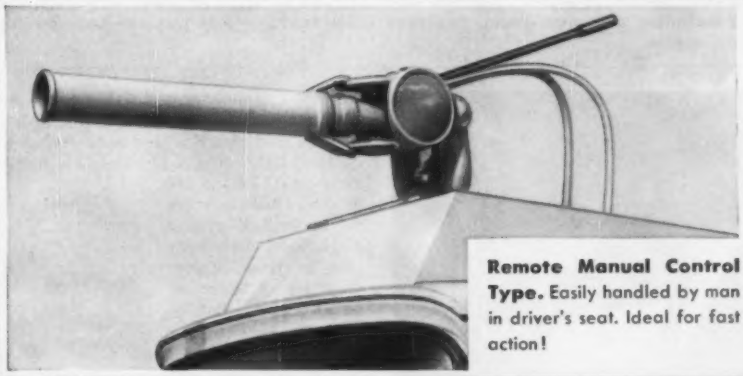
Socony Mobil Refinery, Augusta, Kan. | Fairchild Aircraft Corp. | Cuba, N. Y. Fire Department | Royal Canadian Navy | Dayton, Ohio, Airport

Specialty Turrets on the Market!

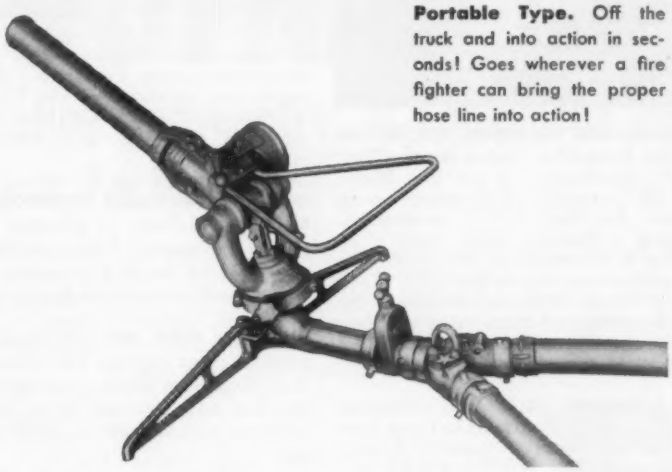
On the truck or on the ground, fire fighters can hit fires *harder* using ROCKWOOD Turrets! At airports and refineries . . . in municipalities and throughout industry . . . these advanced-design fire-fighting aids are constantly proving their ability to extinguish fires faster.

The reason is simple. ROCKWOOD Turrets provide plenty of both volume *and* versatility. They're designed to fight fires four ways: With FogFOAM . . . Solid FOAM Stream . . . WaterFOG . . . Solid Water Stream. What's more, all are easily adjustable on the fire line to meet changing fire conditions.

Produced by the world's largest manufacturer of specialty Fire-Fighting Turrets, ROCKWOOD Turrets are designed to give fire fighters an extra edge of efficiency on *most* types of fires. Make sure your department has the best tools to work with. Get full details on the complete line of fire-fighting products. Mail coupon now.



Remote Manual Control Type. Easily handled by man in driver's seat. Ideal for fast action!



Portable Type. Off the truck and into action in seconds! Goes wherever a fire fighter can bring the proper hose line into action!

ROCKWOOD SPRINKLER COMPANY

Engineers Water... to Cut Fire Losses

ROCKWOOD SPRINKLER COMPANY
A Division of the Gamewell Company
Portable Fire Protection Division
511 Harlow Street, Worcester 5, Massachusetts

Please send me your illustrated booklet on Rockwood Fire-Fighting Products

Name.....*Title*.....

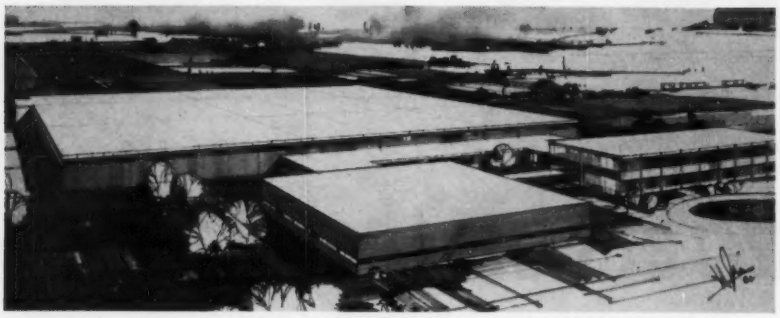
Company.....

Street.....

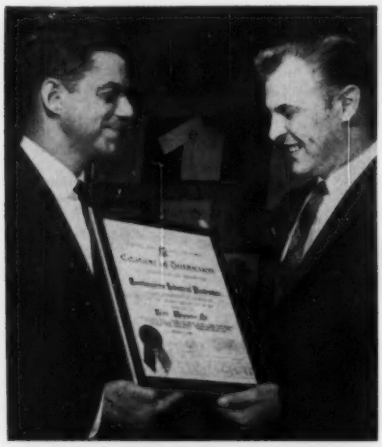
City.....*Zone*....*State*.....

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers Notes...



Flexonics Corp. has selected a 50-acre tract in Bartlett, Ill., on which to build the new headquarters for all its general offices, manufacturing operations and research and development activities. The new structure will incorporate about 325,000 square feet including a modern plant, two-story office building and research and development center.



SOUTHWESTERN INDUSTRIAL ELECTRONICS CO. has received a citation for the "best graphic production" in the Best Magazine Ad Category of Houston's recent Graphic Arts Hall of Fame competition. Pictured is Norman Saxer (right), receiving it in behalf of the Advertising and publications Department, SIE, a division of Dresser Industries. Presenting the award is Herschel Maltz, vice president of Houston Paper Co. and president of the Hall of Fame Committee.

BELL & HOWELL CO. and its subsidiary, Consolidated Electrodynamics Corp. have merged into a single, expanded division for research. The new Corporate Research Division will have 30 percent more personnel than the two previous departments combined. Dr. Charles F. Robinson will be director of research, John G. Heiland associate director, and Dr. Kenneth W. Gardiner assistant director.

THE ELECTRI-FLEX CO., has completed a move into its new plant at Roselle, Ill. The new brick building provides 65 percent more floor space for all company operations. About 10 percent of the space will be for offices.

HAGAN CHEMICALS & CONTROLS, INC. has named **Edgar G. Paulson** manager of process and waste water engineering for its Hall Laboratories Division. He will be responsible for extending Hall's services to the field of stream pollution abatement and to those industries using water as an integral part of the manufacturing process. He will work closely with sales and field engineers in Hall's district offices and sub-offices throughout the United States and Canada. Paulson is a chemical engineering graduate of the University of Pittsburgh, and joined Hall Laboratories in 1953. He is a member of AIChE.

Paulson

GENERAL AMERICAN TRANSPORTATION CORP., has licensed its chemical nickel-plating processes to Union Carbide Nuclear Co., for use in government atomic energy facilities operated by Carbide.

ALUMINUM FOILS, INC. has almost completed a plant addition which will more than double the firm's aluminum capacity. The addition will be a one-story structure covering about 13,000 square feet.

THE AMERICAN FORGED FITTING & FLANGE ASSOCIATION has moved its offices to 333 North Michigan Ave., Chicago. The national industry trade group's telephone number is CE 6-0633.

NEWPORT INDUSTRIES CO. has appointed **Arnold A. Arndt** plant manager, Pensacola operations. A registered professional engineer, Arndt is a chemical engineering graduate of the University of North Dakota.

FISCHER & PORTER CO. has appointed **R. Henry Seelaus** vice president. He joined the company in 1955 as controller, was named secretary and treasurer in 1957, and joined the board in 1959. He will continue as company secretary.

HYDROMATICS, INC. has named **Austin F. Platt** national sales manager. Formerly with the Hammel-Dahl Division, General Controls Co., he joined Hydromatics as district sales engineer, New York.

THE ELECTRIC AUTOLITE CO.'s Wire and Instrument Division has named **John M. Gerber** general manager and **Edward A. McNally** manager of division plants at Port Huron, Mich., and Hazelton, Pa.

BURGESS-MANNING CO.'s Industrial Silencer Division has named **Louis G. Halla** manager, Western District sales offices, Los Angeles. Hallas was formerly a sales engineer. **H. L. Harris** becomes Southern District sales manager.

PETROLITE CORP. has acquired all assets of the Internuclear Co., Clayton, Mo. Internuclear will continue nuclear engineering activities, operating as a wholly owned subsidiary of Petrolite—but will retain its present corporate indentity.

VINSON SUPPLY CO., Houston, has named **R. L. Murphy, Jr.,** sales representative. He attended Texas A & M College and The University of Texas School of Petroleum Engineering.

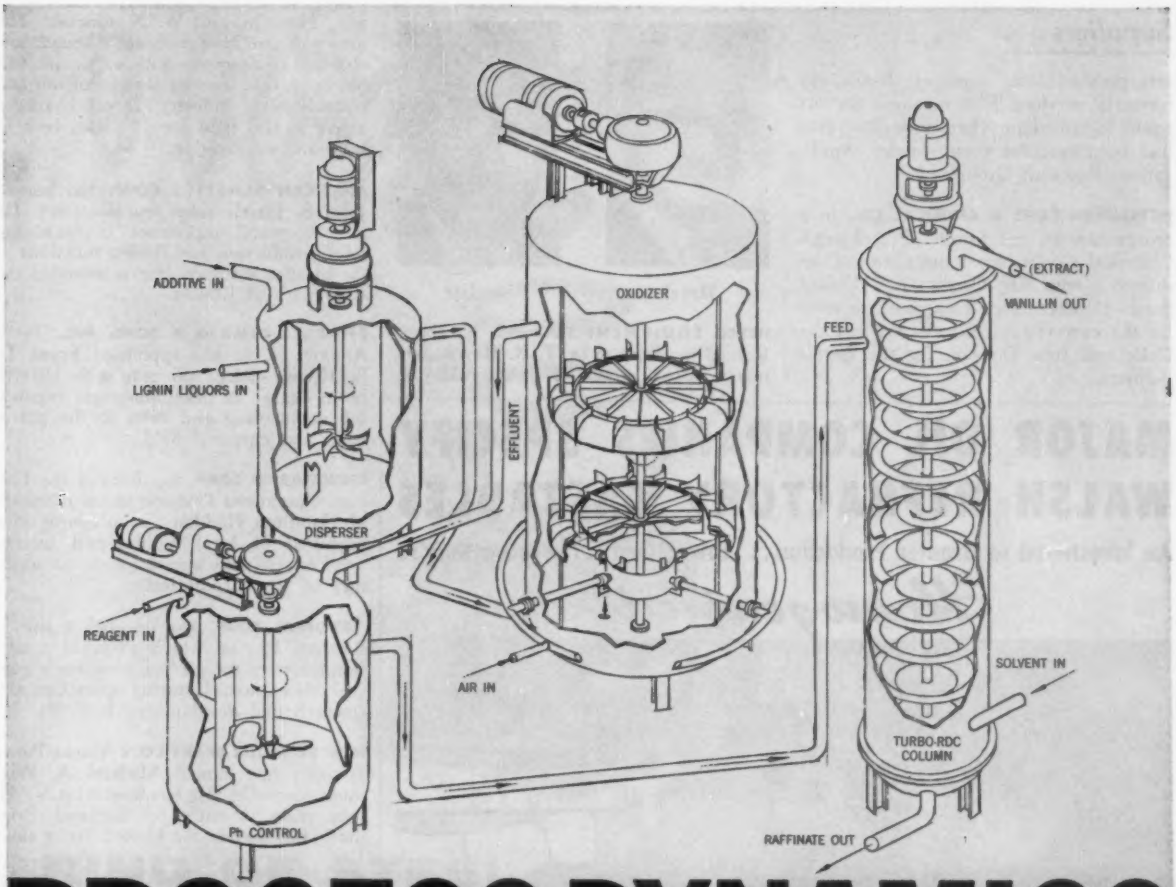
FOOD MACHINERY AND CHEMICAL CORP. has appointed **Walter J. Blair** vertical pump product sales manager, Peerless Pump. Hydrodynamics Division. He will be in charge of planning and supervising the sales activities for the complete line of vertical pumps manufactured by Peerless. Blair joined Peerless in 1949. He has served as a sales engineer, Los Angeles area, and, for the past several years, has been product sales manager of the process line of pumps.

Blair

BLAW-KNOX CO.'s Buflovak Equipment Division reports that **Raymond H. Lewis,** 52, general sales manager, died April 12. With the company 25 years, he had been general sales manager since 1957.

EQUIPMENT SALES CO., INC.'s Fluid Power Division, Atlanta, Ga., has been named a distributor of Parker industrial hose fittings, made by Parker-Hamifin Corp.

HEYDEN NEWPORT CHEMICAL CORP.'s Heyden Chemical Division has named **T. H. Risch** field sales manager and **G. T. Rob-**



PROCESS·DYNAMICS

A new concept for evaluation and control of **Equipment** and **Process Performance**

General American's wide diversification permits the design of equipment for *controlled performance* and *process in transport*. This diversification plus specialized experience and extensive laboratory facilities assures you of correct equipment construction and maximum utilization of automated systems.

Our engineers, with their broad experience in equipment and process specialties, are ready to work with yours to provide any of the listed equipment and systems, and to install them anywhere in the world.

Unified responsibility as provided by General American means greater efficiency, fewer complaints, improved coordination and far less down-time than you can possibly get when your equipment is furnished by a variety of suppliers.

Process Equipment Division

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle Street
Chicago 3, Illinois
Offices in principal cities

TURBO-MIXER GENERAL AMERICAN TRADE MARK

TURBO-MIXERS—LOUISVILLE PROCESS EQUIPMENT—TRAYLOR ENGINEERING—FULLER COMPANY—DRACCO DIVISION—SUTORBILT—KANIGEN CHEMICAL PLATING—PLATE & WELDING—WIGGINS CONSERVATION STRUCTURES—FIELD ERECTION DIVISION—blowers • compressors • conservation systems • conveying systems • coolers • crushers • cryogenic equipment • crystallizers • dewatering presses • dryers • dust control equipment • evaporators • extraction equipment • fans • fractionating columns • gas absorbers • gasholders • mixers • preheaters • pressure vessels • pumps (gas and vacuum) • rock product processing equipment • storage tanks (floating, fixed and lifter roofs)

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

erts product sales manager. Risch was formerly product sales manager for organic intermediate chemicals. Roberts had been assistant group leader, Applications Research Group.

PITTSBURGH COKE & CHEMICAL CO., in a reorganization, has formed Pittsburgh Chemical Co. to serve the chemical industry, Green Bag Cement and United States Concrete Pipe companies to service the construction industry, and the Coke and Iron Division for the metals industry.

Heyck

Sinclair

HEYCK EQUIPMENT CO., INC. has been formed in Houston by **T. R. Heyck,** formerly joint owner of Johnson-Heyck, Inc., Houston, and **W. N. Sinclair.** The firm will distribute nationally known mechanical equipment—with particular emphasis on that used by the petroleum and petrochemical industry. Heyck has been active in this field for 35 years, both in sales and engineering.

AMERICAN PLASTICS CORP. has named **John S. Harris** sales representative. He has 10 years' experience in managing sales, production and design functions in the plastics industry. Harris attended the University of Illinois.

CHARLES SIMKIN & SONS, INC., Perth Amboy, N. J., has appointed **Frank D. St. Hilaire** vice president of sales. He will be in charge of developing and expanding engineering and sales in the petroleum and chemical field.

CHEMSTRAND CORP. has formed the Foreign Operations Division under direction of **Hamilton Hadden, Jr.,** presently vice president of legal, public and foreign services. He will also continue as secretary of the corporation.

FLEXONICS CORP. has selected a site in Bartlett, Ill., on which to build a new headquarters for all the company's general offices, manufacturing operations and research and development facilities.

NEW YORK AIR BRAKE CO.'s Aurora Pump Division has named **Michael A. Prigmore** controller. He has been with NYAB four years. A native of England, Prigmore, has been in the United States since 1955.

WOLVERINE TUBE DIVISION has named **R. C. Crowe** manager of product sales. He was previously manager, New York District. Crowe will be responsible for the sale of all division products on a national basis.

KELITE CORP. has named **Robert F. Ryan** manager, Midwestern Operating Division. He will manage sales and coordinate the Technical and Internal Control departments at the company's Chicago facility, where he will be senior executive.

HEAD WRIGHTSON PROCESSES, LTD. has formed the Industrial Furnace Division to supply furnaces to the petroleum and chemical industries. Offices of the new division will be at 20-24 Old St., London, E.C.I.

CATALIN CORP. OF AMERICA has completed its expansion of facilities to produce antioxidents. The program included a 40-percent increase, bringing capacity to six million pounds per year.

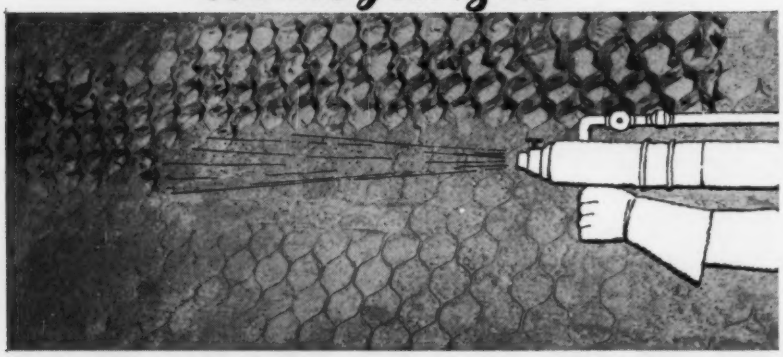
C-E-I-R, INC. has opened a Southwest Region office in Houston. Operations in Houston were speeded up because of a contract with an oil company to develop a large-scale data processing system for a high-speed computer.

CONSTRUCTORS JOHN BROWN, LTD., London, have opened permanent New York offices at 50 Rockefeller Plaza. **A. J.**

MAJOR OIL COMPANIES SPECIFY WALSH REFRACTORY CASTABLES

An Investment in Greater Production . . . Lower Cost . . . because they're

"Homogenized"



Perfect balancing and blending—a marked uniformity of grain structure for absolute homogeneity is just one of the extras in Walsh Refractory Castables for the refining industry. Together with superior bonding qualities, maximum resistance to abrasion, excellent compaction, low rebound loss and high modulus of rupture, you get all the wanted characteristics that result in more efficient service throughout a longer life. There is a light weight insulating, high temperature service type, or iron and sulphur-free castable with suitable "K" factor to meet every refinery need—whether for airgunning, pouring, or trowelling—that will do your job better at less cost.

WEAR-RESISTANT TYPES

H & B CASTABLE
ALSO AVAILABLE—Super Castable No. 32 (iron-free)
HI-AL CASTABLES—(Tabular Alumina)

LIGHT WEIGHT INSULATING TYPES

LITE-WATE No. 70, for one-shot lining, 70 lbs./cu. ft.
LITE-WATE No. 50, for back up, 50 lbs./cu. ft.
LITE-WATE No. 50 NISF (Iron and Sulphur-free)

Complete technical data, directions for airgun application, mixing, pouring, curing, drying, etc. are contained in fully illustrated brochure. Write for your free copy today.

WALSH REFRACTORIES CORPORATION

101 Ferry Street • St. Louis 7, Missouri

For over 60 years manufacturers of high grade refractories

RING OF STEEL

Defies Pressure Times Ten

The Flexitallic gasket in the bonnet joint of Hancock Steel Gate Valves cannot blow out even if pressures exceed ten times the rating of the valve. Valve maintenance and equipment down-time are greatly reduced. Made of a spiral-wound ribbon of stainless steel with asbestos filler, the gasket has spring-like compressibility — cannot be flattened.

Only the specially-designed Hancock bonnet joint with built-in compression limit can make full use of the positive sealing power of this ring of steel. Such advanced valve engineering is one example of total Hancock quality that assures trouble-free performance. Your nearby industrial supply distributor will gladly explain every economy feature of Hancock Steel Gate Valves. Phone him today.

Hancock 800# Steel Gate Valve, Type 950. Sizes: ¼" thru 2".

HANCOCK STEEL VALVES

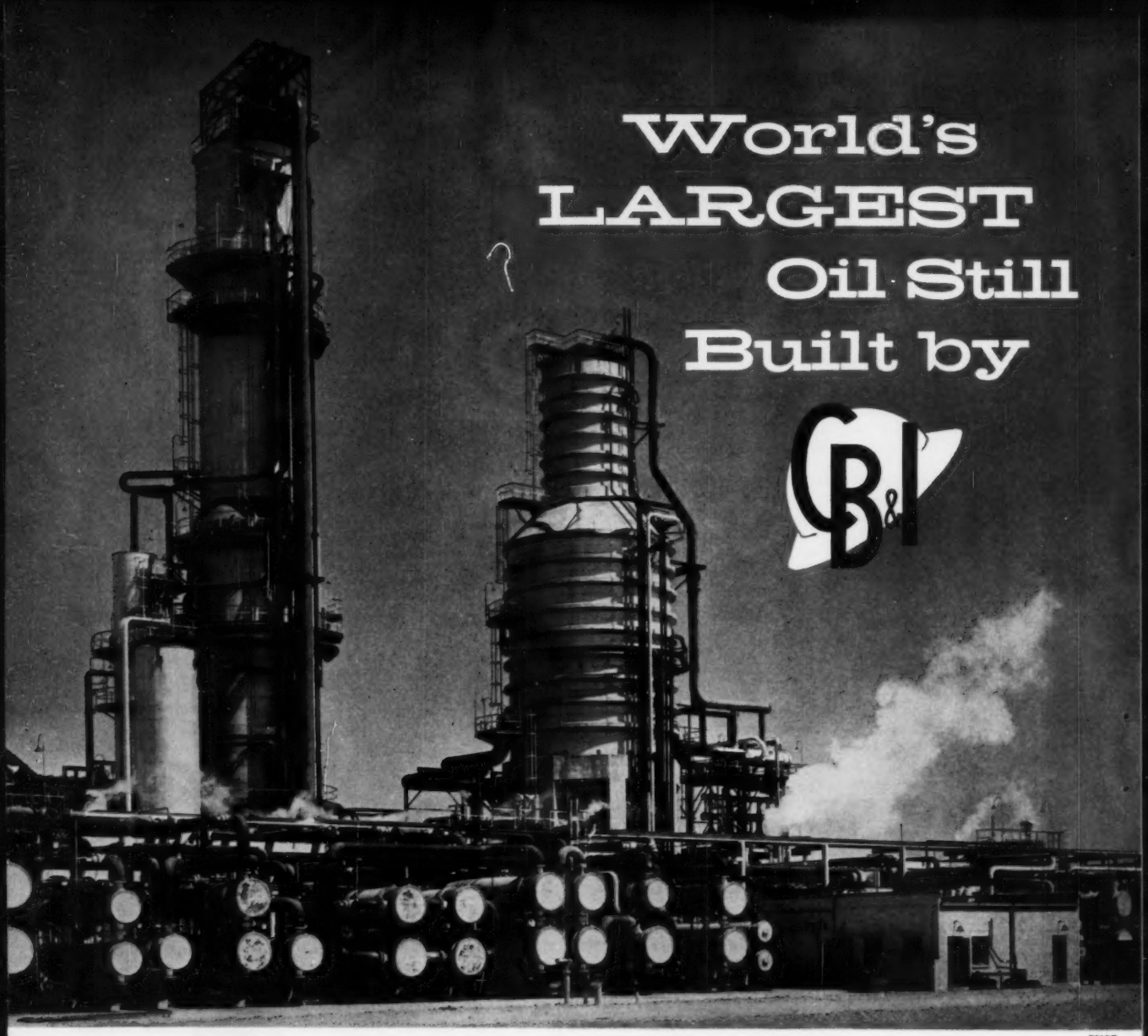
A product of

MANNING, MAXWELL & MOORE, INC.

Valve Division • Watertown, Massachusetts

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

For more data on advertised products, use Readers' Service Cards, last page.



P91CB

The world's largest crude oil pipe still . . . which has a capacity of 140,000 barrels a day . . . utilizes a 173-foot high primary fractionator tower and 145-foot high vacuum fractionator tower, both built by Chicago Bridge & Iron Company. The new processing unit recently went on-stream at a major midwestern refinery to replace nine smaller, obsolete stills. The towers, both completely radiographed and stress relieved, were furnished through Arthur G. McKee Company.

CB&I *coordinated services* will prove invaluable in projects of magnitude that you may be planning. By blending their individual talents . . . research, engineering, fabrication and erection specialists produce structures which meet the most exacting specifications.

If you demand the best . . . you can't be satisfied with less than CB&I *Craftsmanship in Steel*, skillfully developed over the past seven decades. For details, write our nearest office.

CHICAGO BRIDGE & IRON COMPANY

CBI

332 SOUTH MICHIGAN AVENUE
CHICAGO 4, ILLINOIS

OFFICES AND SUBSIDIARIES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

Suppliers . . .

Smith will manage the new office. He has been in Europe several years promoting a line of distillation and absorption plates.

NALCO CHEMICAL CO. has named **Dr. Robert H. Elkins** manager of corporate research. He will be responsible for corporate research work, and will assist in projects aimed at developing new products and processes. Before joining Nalco, Dr. Elkins was associated director of Borg-Warner Research Center, where earlier he had been manager of organic and polymer chemistry. He previously had been a research chemist for Standard Oil Co. of Ohio, Great Lakes Carbon Co. and Sinclair Research Laboratories.

Elkins

ARMOUR INDUSTRIAL CHEMICAL CO. has named **Walter Sindewald** derivities sales representative in Indiana, Western Michigan, Western Ohio and South Chicago. With the company since 1956, he was formerly in charge of sales, Philadelphia area.

ROYAL MANUFACTURING CO., INC. has started production of blown containers at a recently acquired plant in Hamilton Township on the outskirts of Trenton, N. J. The 46,000-square-foot building was owned by Whitehead Manufacturing Co.

MORTON CHEMICAL CO. has named **Frank K. Hoover** Chicago District sales manager, industrial chemicals. He fills the position held by **Wayne Michael,** recently named manager, organic chemicals.

CHICAGO BRIDGE & IRON CO. has elected **Edward S. Fraser** vice president of manufacturing. He had been in charge of manufacturing operations for the past six months. Fraser has been with C B & I since 1939.

J. C. CARTER CO. has acquired all the assets of W. M. Lanagan Co., Inc. J. C. Carter has added an additional 10,000 square feet of administrative and engineering space to accommodate the newly absorbed firm.

PARKER SEAL CO. has named C. E. Conover & Co., Inc., Hasbrouck Heights, N. J., distributor for New Jersey, New York, Rhode Island, Southern Connecticut, and Eastern Pennsylvania.

THE COOPER-BESSEMER CORP. has named **John C. Dangler** sales engineer, East-Central Sales District. He had previously been with Oster Manufacturing Co., Cleveland, since 1947.

FULLER CO.'s Draco Division has started construction of a modern two-story addi-

MOBILE GAS STORAGE

WHERE YOU WANT IT FAST WITH

TW GAS TRANSPORTS

"Mobile" is defined in the dictionary as being "characterized by ease of movement — capable of being readily moved about." This is a perfect explanation of the principle advantage of Taylor-Wharton Gas Transports.

Along with mobility, the transports afford semi-permanent storage of gases in tubes, with capacities up to 100,000 cu. ft. or more depending upon the size and type.

Each modern Taylor-Wharton Gas Transport consists of normalized seamless steel pressure vessels, inspected and tested to I. C. C. 3A-2400 specifications. The vessels are rigidly grouped and mounted on a special trailer chassis with either single or tandem axle. The transport is delivered ready for use, with tubes manifolded to a common outlet in a rear-mounted weatherproof cabinet.

Catalog No. 58 gives complete details on this practical system for flexible gas storage. Write for it today.

More than a Century in Harrisburg 2, Pa.

H HARRISBURG STEEL CO.

Division of HARSCO CORPORATION

CYLINDERS TUBES FLANGES COUPLINGS

For more data on advertised products, use Readers' Service Cards, last page.

Where PRODUCT PURITY is important, protection gets a hand from Alcoa

When protection against contamination from *any* source is vital, take a look at what Alcoa aluminum electrical rigid conduit offers. ¶ It needs *no* protective coating, because it forms its own—an oxide film that repairs itself when damaged. ¶ It's corrosion-resistant—stands up particularly well against acids commonly present in food plants: citric, acetic, tannic. And the compounds that might form when aluminum is used are in most cases *nontoxic*, completely safe. ¶ What else? Aluminum is lightweight (weighs about 1/3 as much as steel), so it's easier to install. Alcoa conduit is also nonmagnetic, nonsparking, and neat appearing. ¶ Consider all costs—initial, installation, maintenance—plus long service and you'll see why Alcoa aluminum conduit is a sound investment. ¶ For full details, contact one of our nearby representatives. Or write to Rome Cable Division of Alcoa, Dept. 19-50, Rome, New York.

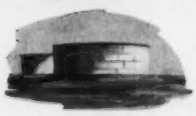
◀ ADDED PROTECTION against product contamination is provided by Alcoa aluminum conduit. It needs no protective coating, resists corrosion, and is nontoxic.

ROME CABLE
DIVISION OF **ALCOA**

AMERCOAT: COMPLETE CORROSION PROTECTION

No one coating is ideal for all applications. A coating which gives outstanding protection against chemical fumes in a refinery may fail completely when exposed to salt water splash, high humidity or hot sun on an offshore rig in the Gulf area.

In order to provide complete corrosion protection, the Amercoat Corporation manufactures more than 40 completely different products, each formulated to give maximum corrosion protection for specific applications. As new processes and techniques alter exposures and requirements, Amercoat's continuing research develops new products to meet those requirements. Also, advanced research and testing upgrades and improves existing products to maintain maximum protection and enduring, maintenance-free life. Amercoat protective coatings, ranging from vinyls to epoxies to phenolics, are tailor-made for long-range protection and economy in tough applications.



DIMETCOTE—a 100% inorganic, zinc silicate coating for severe weather exposure, salt water spray, fresh water, etc.
Typical applications: Offshore rigs, floating roof tanks, steel structures, pipelines, cooling tower piping, etc., and as a permanent primer.

AMERCOAT No. 33—A vinyl maintenance coating unexcelled for water immersion, chemical spillage or corrosive fumes.
Typical applications: Tank exteriors, pipelines, etc.

AMERCOAT No. 78—A catalyzed coal tar epoxy for exceptional resistance to severe chemical exposures.
Typical applications: Sour crude storage tanks, pipelines

BONDSTRAND—A corrosion resistant, high strength glass reinforced epoxy pipe.
Typical applications: Gathering lines, cooling lines, tanker loading lines, oil and gas lines.

Technical data available on request. Write to:

Amercoat® CORPORATION

Dept. VE
4809 Firestone Blvd.
South Gate, California

124

921 Pitner Ave.
Evanston, Ill.

360 Carnegie Ave.
Kenilworth, N.J.

2404 Dennis St.
Jacksonville, Fla.

6530 Supply Row
Houston, Tex.

Suppliers . . .

tion to its main plant, which will house three departments. More than 18,000 square feet of new area will bring plant space to 85,000 square feet.

REPUBLIC FLOW METERS CO. has named **Wolfgang W. Berger** field research engineer. To headquarter in the Republic-Rockwell Houston office, he will direct field research projects throughout the Middle South in the petroleum and chemical processing fields in behalf of Rockwell meters and valves and Republic instruments and controls. Berger joined Republic in 1939 and has worked in manufacturing, development engineering, field service engineering, and product design. He attended Illinois Institute of Technology.

Berger

SONNEBORN CHEMICAL AND REFINING CORP. has appointed **Dr. Charles E. Leyes** director of building products laboratories. He joined Sonneborn from Celanese Corp. of America's Plastics Division, where he was assistant to the technical director.

MINNEAPOLIS-HONEYWELL REGULATOR CO. has transferred **Vice President Henry F. Dever,** head of the Industrial Products Group, to Minneapolis from his Philadelphia location. **James S. Locke** becomes vice president and general manager, Brown Instruments Division.

BLACK, SIVALLS & BRYSON, INC. has named **Edward W. Reif** sales manager, Controls Division. Since 1952, he has been district sales manager, Oilfield Equipment Division, Midland, Texas, Division. He has been with the firm since 1942.

REYNOLDS METALS CO. and **NATIONAL MARINE SERVICE,** New York, plan to build the world's two largest aluminum barges for transportation of sensitive liquid chemicals. They will each handle 12,500 barrels and carry 1,600 short tons.

BORG-WARNER CORP.'s Byron Jackson Division has named **Harold B. Bruwelheide** controller and treasurer. He joined Jackson in 1957, after being with Carrier Corp. and Dresser Industries.

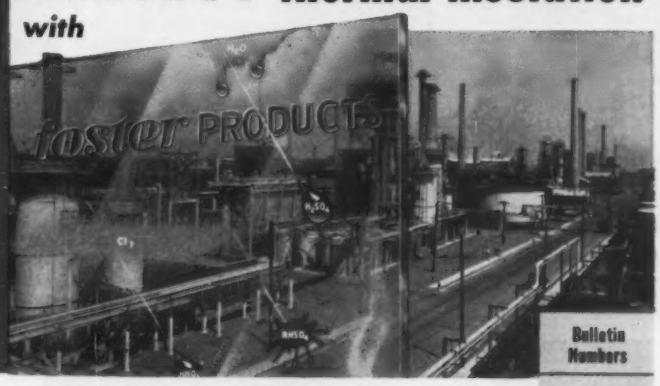
PHILIPS ELECTRONIC INSTRUMENTS CO. has opened a new office at 1299 Bayshore Highway, Burlingame, Calif. The staff includes **Don Rodgers, Alexander Gobus** and **Jaun Pradenas.**

AMERICAN ALCOLAC CORP., Baltimore, has elected **W. Alec Jordan** to the board. A former editor of *Chemical Week,* Jordan currently heads the New York public relations firm, W. Alec Jordan Associates.

MINNEAPOLIS - HONEYWELL REGULATOR CO.'s Brown Instruments Division has ex-

foster and Process Industries

PROTECT thermal insulation with



				Bulletin Numbers
mastics	60-24	CORK-FILLED MASTIC	Insulating mastic for storage tanks	M-3-B
	60-25/26	C.I. MASTICS	Asphalt vapor-barrier weathercoats	M-3-A, B, C
	60-38/60	FIRE-RESISTIVE MASTICS	UL-listed non-asphaltic flexible weathercoats	M-3-A
	*60-30N/60N	FIRE-RESISTIVE MASTICS	Non-asphaltic flexible weathercoats with non-flammable solvent	M-3-A, C
	60-40	INSULFAS	Fire-resistive insulating mastic for ducts and vessels	M-3-B
	60-80	SAFETEE MASTIC	UL-listed asphalt "breather" weathercoat	M-3-A
	60-99	HiLASTIC MASTIC	Flexible asphalt weathercoat of HiLastic system	M-3-D
	90-07	H.I. MASTIC	Fibrated asphalt emulsion "breather" coating	M-3-A
adhesives	*81-42W	LAGFAS	Economical adhesive for lagging canvas on insulated piping	A-3-A
flashings	30-14	ASPHALT SEAM SEALER	Chemical and water-resistant flashing compound	F-3-A, C, E
	30-43	HEAT-RESISTANT SEALER	For flashings at temperatures to 400°F	F-3-E
	30-45	FOAMSEAL	Flexible sealer for dual-temperature insulations	F-3-C, E
	30-46	INSULATION SEALER	Flexible sealer for year-round use	F-3-B, C, D
	60-25	C.I. MASTIC	Asphalt sealer for vapor-barrier on pipe jackets	F-3-D
	*60-30N	FIRE-RESISTIVE MASTIC	Non-bleeding, non-flammable, elastic sealer	F-3-A
coatings	*30-36	SEALFAS	Light-colored fire-resistive, abrasion-resistant coating	C-3-A, C
		*LAGTONE	Fire-resistive coatings in white and colors	C-3-B
		*VITECT VINYL	Chemical-resistant coatings in colors	C-3-A, B, C
		VITECT EPOXY	Tough, chemical and solvent-resistant colored coatings	C-3-A, B, C

SOLD BY AMERICA'S LEADING INSULATION DISTRIBUTORS AND CONTRACTORS

* THESE PRODUCTS (60/30N, 60/60N, 81/42W, 30/36, LAGTONE, VITECT VINYL) MEET THE FLAME SPREAD REQUIREMENTS OF GENERAL SERVICES ADMINISTRATION WHEN TESTED IN ACCORDANCE WITH INT. FED. STD. NO. 00136 (COM-N.B.S.)
60/30, 60/60, 60/80 ARE ALSO LISTED BY UNDERWRITERS' LABORATORIES.

The Bulletins listed above are designed to help you solve specific insulation-protection problems. For copies, simply note the numbers on this coupon and mail.

foster COATINGS · SEALERS · ADHESIVES

BENJAMIN foster CO.
Division of Amchem Products, Inc.

4635 W. GIRARD AVE. • PHILA. 31, PA.

Benjamin foster Co.

Please send me the Bulletins for Process Industries which I have noted. I understand there is no obligation.

Name _____

Company _____ Title _____

Street Address _____

City _____ Zone _____ State _____

Bulletin _____ _____ _____ _____ _____ _____ _____

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

panded facilities for production of thermocouple and other pyrometer supplies. Operations in Philadelphia have been streamlined and moved to new quarters, and a new plant has been completed at Los Angeles.

MANNING, MAXWELL & MOORE, INC. has formed a Gauge and Instrument Division and a Valve Division, with **Philip T. Tryon** general manager of the former and **Clyde E. Dephouse** in charge of the latter. Both have been with the company a number of years.

ELGIN METALFORMERS CORP., Elgin, Ill., has appointed John A. Green Co., Dallas, engineering-sales representative in the Southwest. The new representative will service industrial and electronic accounts.

THE O. L. OLSEN CO., INC. has celebrated passage of the century mark by opening new offices in the Baldwin Bldg., 3813 Buffalo Speedway, Houston. The new offices accommodate engineering and administrative sections.

GENERAL ANILINE & FILM CORP. has given special awards to 13 employes for outstanding achievements during 1959. The awards, totaling $11,500 were persented at work locations of the winners.

NEW!
Portable Model C-7 operates 8 hours at rated capacity of 75 lbs./hr.

MODEST COST!
For industrial plants and small users.

Compact refractory-lined incinerator

OPERATES TWICE AS LONG
as other units of similar capacity

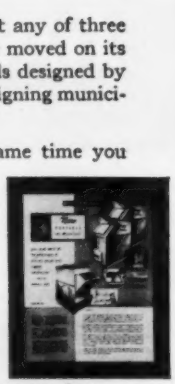
Combustible trash is less apt to accumulate when it can be burned quickly and safely to fine ash on the spot. Convenient 24" x 20" charging door permits passage of even large cartons without crushing.

Flexible design fits any layout. Stack may be connected at any of three locations to fit various installation requirements . . . can be moved on its sturdy steel skids. This is one of several "packaged" models designed by Plibrico engineers . . . the same engineers responsible for designing municipal incinerator plants.

Plan now to eliminate health and fire hazards at the same time you reduce hauling and space costs.

SEE OUR CATALOG in REFINERY CATALOG

SEND FOR CATALOG 78 showing data on small portable incinerator models



Plibrico INCINERATORS

Plibrico Sales and Service Throughout the World

PLIBRICO CO., 1812 Kingsbury, Chicago 14 • Canadian Plant: Toronto, Ont.

REFRACTORY PRODUCTS • ENGINEERING • CONSTRUCTION

AUTOMATIC SPRINKLER CORP. OF AMERICA's Special Hazards Department has named **R. J. Buchanan** manager. He will direct Automatic Sprinkler's first sales and development of fire protection systems for industrial plants.

BECKMAN INSTRUMENTS, INC.'s subsidiary, Shockley Transistor Corp., Palo Alto, Calif., has been sold to Clevite Corp. Clevite says it made the purchase to augment its activities in the semiconductor component field.

MASTER TANK AND WELDING CO., Dallas, has appointed **Harry Pearson** sales representative. He has spent many years in the LPG industry, and has served in all phases of the petroleum and allied fields in the Southwest.

SAMUEL MOORE & CO.'s Dekoron Products and Synflex Products divisions have named **G. William Dix** Southern California District manager. He was previously a sales representative for Leed Plastic Molding Co., Alhambra, Calif.

UNITED STATES RUBBER CO. has promoted **John V. Glaves** to district sales manager, Houston. He was formerly assistant district sales manager, mechanical goods, Houston branch. He has been with the company since 1948.

NEW YORK AIR BRAKE CO.'s Aurora Pump Division has named **Michael A. Prigmore** controller. He has been with NYAB four years. A native of England, Prigmore studied at Haberdashers' School, London.

CONAX CORP. has appointed **Warren L. Jones** sales manager, industrial products. He joined Conax in 1959, following a long association with Technical Charts, Inc., a subsidiary of Graphic Controls Corp., where he was factory sales manager.

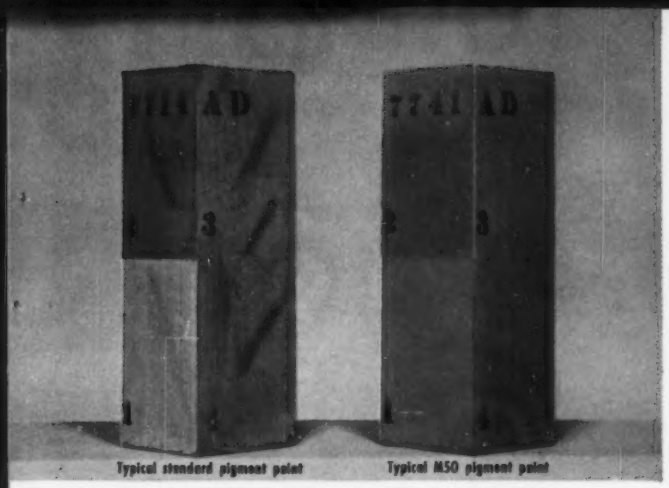
THE CARPENTER STEEL CO.'s Alloy Tube Division has named **John L. Mitchell** branch manager, Chicago, **Stanley L. Hoagland** branch manager, Indianapolis, and **Stephen P. Salarano** branch manager, St. Louis.

KEASBEY & MATTISON CO.'s Industrial Division has appointed **C. Fred Workman** merchandising manager, insulation sales. Previously a salesman in the Houston District office, the new assignment embraces wide-scale promotion.

ALLIS-CHALMERS MANUFACTURING CO.'s Industries Group has appointed **W. C. Henderson** manager, utility sales, and **A. W. Leighton** manager, industrial sales, Los Angeles. Both have been with the company more than 10 years.

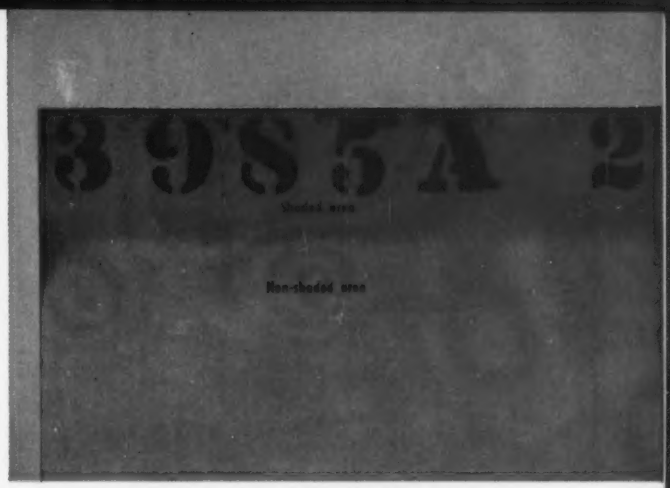
WHITEHEAD METALS, INC. has named **James H. Miller** comptroller and member of the Management Committee. **T. Paul Moore** becomes assistant comptroller. Miller joined the company in 1925 and more in 1936.

W. S. ROCKWELL CO. has established a Plastics Coating Division to provide ther-



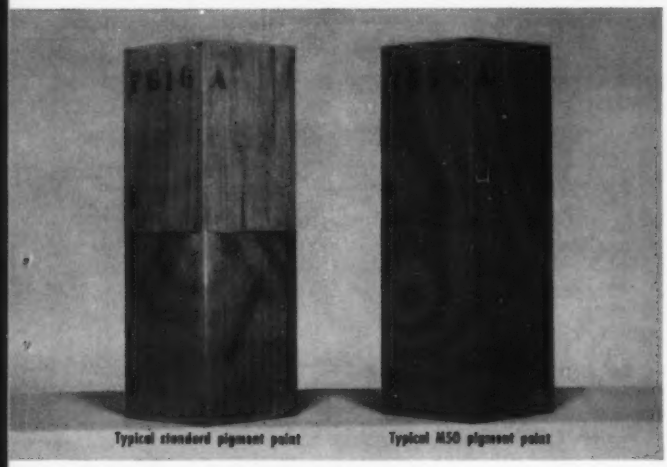
No objectionable whitening from chalking

Contrast these two exposure test panels . . . both show comparable metal finish paints. Same original colors. Same exposure (45° South, 2 yrs., 3 mos.). Notice bright color of *M50* paint, freedom from chalk.



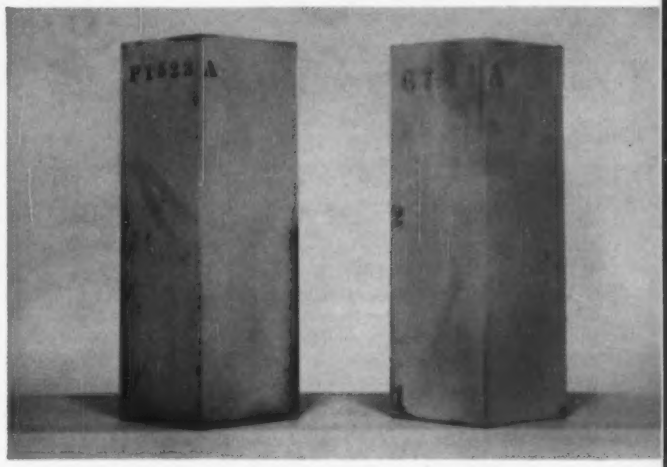
No appreciable fading from light action

Now look at this 9-year exposure test panel of an *M50* paint. Contrast area shaded by wooden panel holder with non-shaded area. Clearly, there has been practically no fading in this 9-year period.



No leaching from water action

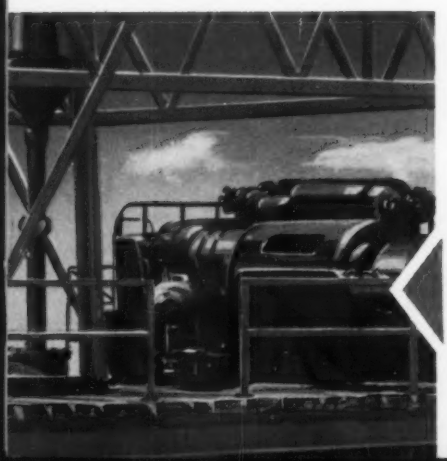
Examine the exposure panel at left. Notice the vertical brushmarks? Rain water leaching of the top coat permits brushmarks in undercoat to show through. In the panel at right, insoluble *M50* pigment prevents this film failure. Exposure 45° South, 2 yrs., 7 mos.



No discoloration in industrial atmosphere

Here are two exposure panels painted from the same can of *M50* paint. Both have been exposed 4 years, 45° South. The right one in normal atmosphere, the other in sulfur-laden industrial atmosphere. Notice no color difference has developed. No bilging.

Proof you get unique color stability in metal protective paints made with M50® pigment



Drilling equipment looks better, needs less maintenance painting when painted with colorful *M50* anti-corrosion paints.

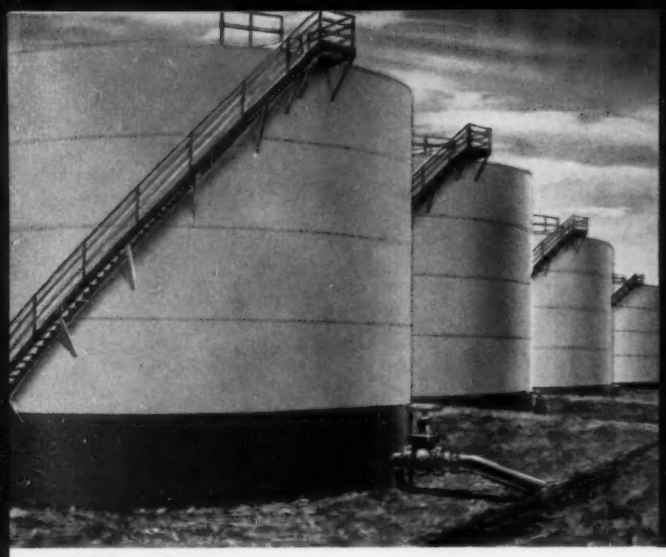
No need to amplify what the four illustrations above show. Plainly, *M50* basic lead silico chromate pigment permits your paint supplier to make paints with more color stability than ever before available in anti-corrosion paints . . . primers as well as finishes.

National Lead exposure tests demonstrate that these paints . . . both standard and deep-coat . . . also provide better and longer lasting anti-corrosion action, and never-before weather resistance. Some of the opportunities these new *M50* paints present are suggested on the following page. You'll think of others.

M50 *an* **oncor** TRADEMARK *pigment development of*

National Lead Company

111 Broadway, New York 6, N. Y.



Public relations.
Attractive tank farms that *stay* attractive longer.

Product identification.
Color-coded drums that *stay* colorful longer.

Two ways to make good use of the superior color stability of M50 pigment anti-corrosion paints

Before the advent of *M50* pigment, those responsible for maintenance painting had to make a choice between colorful appearance and long-lasting corrosion protection.

With *M50* pigment paints, exposure experience proves, this compromise is no longer necessary. *M50* paints have weather resistance . . . stay bright and colorful . . . and *at the same time* provide superior corrosion protection. With these unusual paints, color stability problems . . . leaching, fading, whitening, darkening from bilging . . . are eliminated. Now, with *M50* paints, you can have maximum anti-corrosion, maximum durability and, at the same time, long-lasting good appearance.

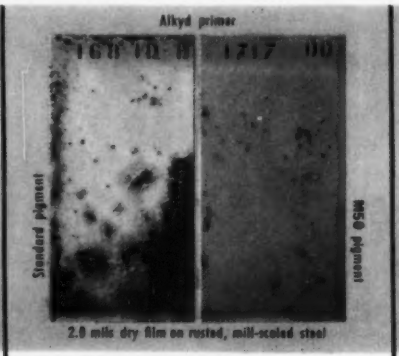
The illustrations above suggest two areas in which the combination of superior anti-corrosion action and superior color stability found in *M50* pigment paints can pay off handsomely. Note that in both, service is severe and colorful colors are needed. With *M50* paints, you repaint less often.

In your own operations there are bound to be many similar applications where specification of *M50* paints can lower your maintenance painting costs. Ask your regular paint supplier to make up suitable *M50* paints for your requirements.

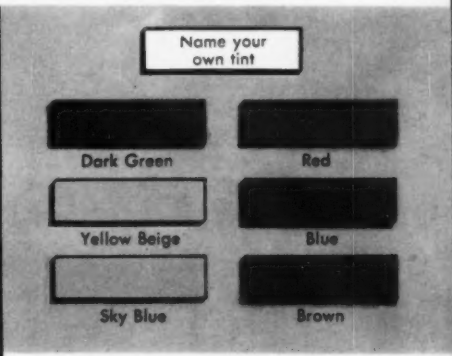
Why M50 Defense in Depth paints give anti-corrosion beyond all former concepts

2 standard pigment alkyd primer coats
1 standard pigment alkyd primer coat
Gray Alkyd Finish Coat
2 M50 pigment alkyd primer coats
1 M50 pigment alkyd primer coat

Exposed 9 years, 45°S. Each coat 1.5 mils
Proved corrosion and weather resistance



Exposed 45°S, 1 yr ind atmos, 1 yr normal atmos.
Proved outstanding for film strength, durability



Colors above available in conventional and heavy-coat paints
A wide range of stable colors can be produced

Are you concerned with tank or structure maintenance painting in your firm? If so, you are invited: (1) to visit National Lead's Sayville, L.I. test station, where you will see the results of the 20 years research that lies behind the *M50* pigment particle and the more than 10 years of exposure testing that lies behind *M50* pigment Defense in Depth paints; (2) to send coupon below for National Lead booklet, "Defense in Depth" and typical *M50* tank paint specifications.

Next time you purchase, specify *M50* pigment paints. Any paint manufacturer can supply you.

M50 Defense in Depth

National Lead Company,
111 Broadway, New York 6, N. Y.

Gentlemen: Please send me the "Defense in Depth" booklet together with typical tank paint formulas and color chips that I can use in specifying M50-type tank paints.

ancor TRADEMARK

Name_____ Title_____

Firm or Dept._____

Address_____

City_____ State_____

DURA SEAL

THE ENGINEERED MECHANICAL SEAL

. . . spells out the answer to your sealing problems

D ecreases maintenance expense

U naffected by corrosives

R otates with the shaft

A djusts itself automatically

S eals abrasive liquids

E liminates scoring of shafts

A daptable to standard stuffing boxes

L essens power costs

For free engineering counsel on your sealing problems . . . write

The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO, MICHIGAN

Suppliers . . .

moplastic finishes on surfaces of metal objects for corrosion resistance or decorative purposes. The division is in Fairfield, Conn.

AJAX IRON WORKS, Corry, Pa., has appointed Mid-Continent Supply Co. distributor for its line of pumps, engines and compressors. The National Supply Co., Pittsburgh, will continue as an Ajax distributor.

AIR REDUCTION SALES CO. has named **J. M. Crockett** vice president of gases. A graduate of South Dakota School of Mines, he has been with the company since 1955. Most recently he managed the Birmingham District office.

BAKER PERKINS CHEMICAL MACHINERY DIVISION, Saginaw, Mich., has named **Richard W. Miller** division project engineer, plastics. He was formerly vice president and production manager, Bakan Plastics, Inc., San Jaun, Puerto Rico.

KAISER REFRACTORIES & CHEMICALS DIVISION has completed a new periclase plant at Midland, Mich. Under construction since last summer, it will produce 45,000 tons of periclase and refractory-grade magnesias a year.

E. F. HOUGHTON & CO. has opened a new plant at 54 Tanfoan Ave., South San Francisco. It will supply industrial oils and chemicals formerly produced at the Houghton plant on Davidson Ave., San Francisco.

A. M. BYERS CO. has appointed **W. E. Weber** Pacific Coast Division manager. A graduate of St. Bonaventure College, he has been with the company nine years —four at the Ambridge plant and five on the West Coast in field service.

BRICE MACHINERY AND CONTROLS CO., Houston, has been appointed sales representative for Allis Chalmers Manufacturing Co.'s industrial machinery and control equipment. Equipment represented will include electrical and general industrial apparatus.

REFRACTORY HAYDITE

Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.
We sell direct to you.

CONSTRUCTION MATERIALS
CARTER-WATERS
KANSAS CITY CORP. & MISSOURI
2440 Pennway Phone GRand 1-2570

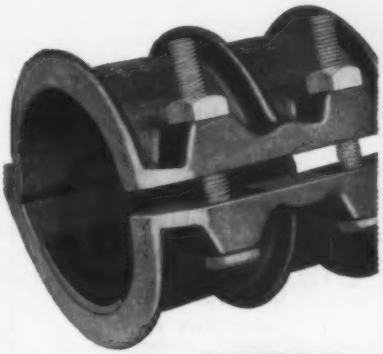
For Speediest Repair of Corrosion Leaks in Pipe
JUNIOR
EMERGENCY PIPE CLAMP

Repair pipe leaks QUICKLY!

Speediest application — slotted lug permits the single plated bolt to slide instantly into place.

A companion to the old reliable Emergency Pipe Clamp that has served industry for a half century, the JUNIOR, a single bolt clamp, is 2⅞" wide. Undersells most band-type clamps.

Made of malleable iron, ruggedly proportioned, with full-length hinge along one side. Formed to exact pipe size—no bending. The recessed pressure-equalizing gasket, entire width of clamp, is cemented in. A lasting installation. 2" pipe size—$1.80; 2½"—$2.20; 3"—$2.30. Write for new circular on the Junior.



SKINNER-SEAL
EMERGENCY PIPE CLAMPS for safe, sure lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12", for steel and C. I. pipe. Stocked by practically all oil supply stores.

Send for catalog!

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

HELP WANTED

PROCESS ENGINEER: Kerr-McGee Oil Industries, Inc. has an opening for a Process Engineer to join expanding Refinery Operations Technical Service Department. Minimum qualifications are BS degree in Chemical Engineering and five or more years experience in oil refineries. Send resume of education, experience and salary requirements to Refinery Division, Kerr-McGee Bldg., Oklahoma City, Oklahoma.

SENIOR
PROCESS ENGINEERS

Permanent employment with an expanding company. Excellent advancement opportunities for men with at least 10 years experience in process design of petroleum and petro-chemical plants.

Send detailed resume to:
G. VICTOR HOPKINS
ARTHUR G. McKEE & CO.
2300 Chester Ave., Cleveland 1, Ohio

MECHANICAL ENGINEER

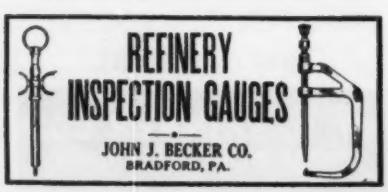
Graduate Mechanical Engineer with minimum of four years experience in petroleum refinery or related engineering. Will be responsible for mechanical design and cost estimate of refinery processing equipment.

Duties will be closely integrated with operation of a modern, independent refinery which includes crude distillation, catalytic cracking, polymerization, coking, hydro-desulfurization, catalytic reforming, alkylation, and utilities.

Send complete resume of education and experience, including salary requirements. All replies confidential.

GREAT NORTHERN OIL COMPANY
P. O. BOX 3596
ST. PAUL 1, MINNESOTA
ATTN: C. L. DRETZKE

FOR SALE



HELP WANTED

REFINERY MAINTENANCE—Two men, one possibly for Maintenance Superintendent, with several years general experience in all phases refinery maintenance: covering, welding, pipe fitting, pump and compressor repairs, instrument, electrical, boiler making, rigging, etc. Mechanical Engineering Degree desirable but not necessary if otherwise qualified. Must be capable of doing work in the crafts themselves, also organizing, training, and supervising our Puerto Rican employees. Salary commensurate with experience and ability. Make application to E. G. Case, Vice-President, Manufacturing, Caribbean Refining Company, Box 2988, San Juan, Puerto Rico.

CHEMICAL ENGINEERS

All Degree Levels Needed
Immediately for Process Design and Economic Evaluation

Apply your abilities to the development and design of new process units in the Petroleum Refining, Chemical Processing, Plastics, and all related fields. Two to five years' experience is preferred. Salary commensurate with experience. Location in Bartlesville, Oklahoma, a modern, progressive, southwestern community.

PHILLIPS PETROLEUM COMPANY
offers you a challenge and opportunity. Do not delay, write - - -

Personnel Procurement
Research and Development Department
PHILLIPS PETROLEUM COMPANY
Bartlesville, Oklahoma

NOTICES - SERVICES

NORMAN O. ELDRED
Consulting Chemical Engineer
P. O. Box 3396, Mdse. Mart Postal Sta.
Chicago 54, Illinois
Complete Petroleum Refinery Design Engineering, Bulk Gasoline and Oil Storage and Terminal Plants, Butane and Propane Storage and Vaporizer Plants Process, Finished Designs, Specifications, Reports, Supervision.

Substantial German Importer wishes connection with independent manufacturer of:

Petrolatum
(green and dark-green)
Petrolatum
(white and yellow, USP)
White oils (USP)
Transformer Oils
Petroleumsulphonate.

Capable producers please reply to Box 336-R, c/o PETROLEUM REFINER, Houston, Texas, U.S.A.

Suppliers . . .

CHASE BRASS & COPPER CO. has elected **Herman H. Kremer** vice president in charge of sales, and a company director. **Walter E. Evans** has been named assistant to the president, and **Paul M. Thomas** has been appointed general sales manager.

ALLIS-CHALMERS MANUFACTURING CO. has combined its Industrial and General Products divisions into a new operating unit called the Industrial Equipment Division. **W. M. Wallace** will be vice president and general manager, and **G. A. Saar assistant general manager.**

ARTHUR D. LITTLE, INC. has appointed **James M. Gavin (Lt. Gen., U.S.A., Ret.)** president of the company. Gen. Gavin joined the firm in 1958 following retirement as chief of Army research and development.

CUTLER-HAMMER, INC. plans to build a new plant at Belmont, Calif., to house its manufacturing, sales and warehouse activities. To replace facilities at San Jose and San Francisco, it will have 35,000 square feet of floor space.

SOUTHWESTERN INDUSTRIAL ELECTRONICS CORP. has elected **Howard S. Gleason** assistant to the president. He was formerly with Stromberg-Carlson Corp. as assistant general manager, Electronics Division.

NORTON CO. has named **Curtis H. Weissinger** project engineer, Refractories Division. With the company 30 years, he was most recently supervisor, Technical Service Department, Refractories Division.

Test Yourself

(Answers to Quiz on Page 262)

CASE NO. 1

Arbitrator Paul H. Sanders ruled:
"The Arbitrator believes that the worker's conduct must be judged in the setting in which it occurred. This setting seems to have been a period of general disturbance and unrest. More importantly, the setting includes an absence of adequate supervision. The worker's conduct does justify discipline. But discharge is too severe under the circumstances. I order reinstatement without back pay."

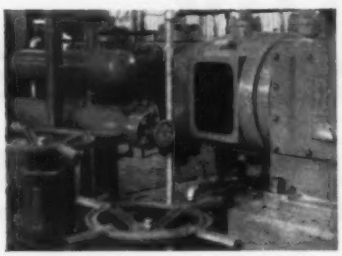
CASE NO. 2

Arbitrator Clair V. Duff ruled:
"There was no immediacy about obtaining the information that Jilling sought. It could have been obtained during lunch hour, or at some other time so as not to interfere with his regular job duties. The supervisor did not act arbitrarily, and Jilling's leaving after being told not to was definitely in violation of the contract. Jilling was properly disciplined."

Pointer oscillation just 1 of reasons for dampening industrial thermometers

It is generally assumed that industrial thermometers are silicone dampened solely to prevent pointer oscillation when used on vibrating equipment. True, the prevention of pointer oscillation is necessary, but actually there are several far more important reasons for the use of dampening fluids.

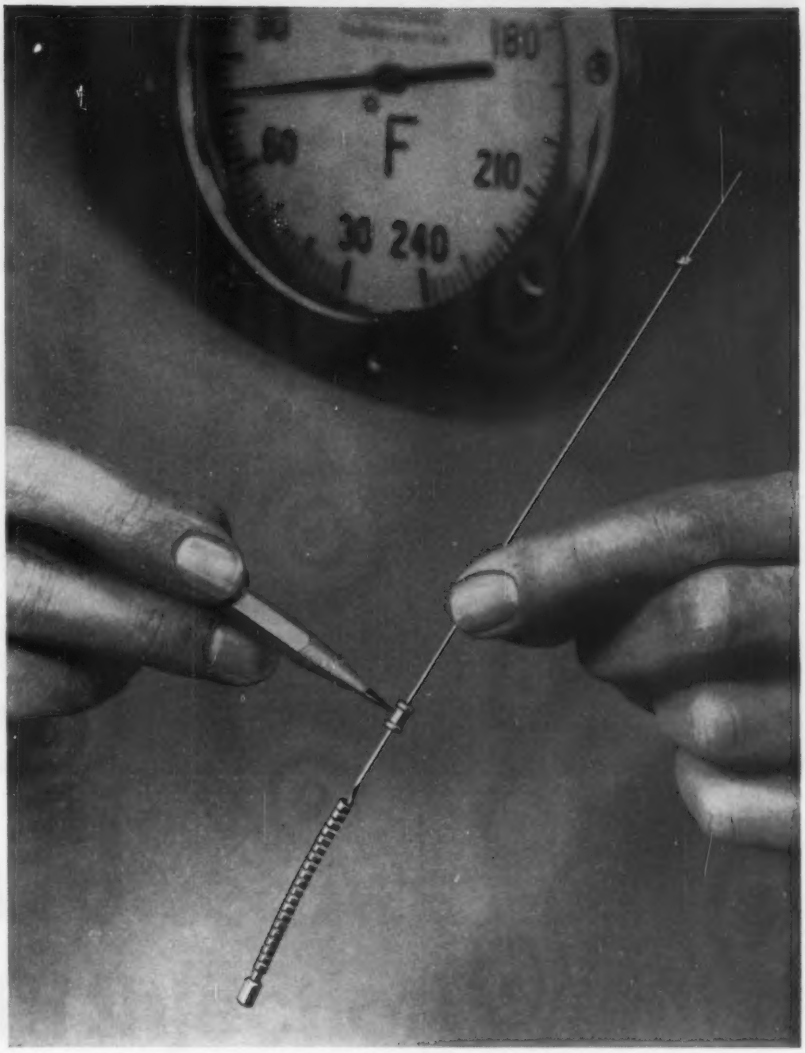
The primary reason for dampening bimetallic dial thermometers is to preserve accurate calibration, especially on the lower temperature ranges where a thinner bimetal element is used. An *un*dampened bimetal element, when subjected to shock or severe vibration, would have a tendency to unwind slightly, throwing the instrument out of calibration. To prevent this, RMC thermometers are dampened by a patented process in which the bimetal element is coated with silicone. The silicone provides permanent protection for the critical bimetal element, holding the coil in place and preventing any unwinding or shifting action. This dampening, of course, also prevents pointer oscillation, eliminating difficult readings. But the main reason for silicone dampening is to help maintain calibration accuracy, and it is therefore quite important to *all* industrial thermometer users.



The RMC thermometer in this photograph is constantly subjected to extreme vibration. It is installed on a two-stage Synthesis Gas Compressor in Atlantic Refinery's Philadelphia Synthetic Ammonia Plant. Only a completely dampened thermometer could maintain its accuracy under such conditions.

There is more, however, to the full dampening story at Rochester Manufacturing Company. RMC carries the procedure one step further with a specially designed bearing which further dampens both the shaft and coil. It also serves as a better guide for the bimetal shaft to keep it perfectly aligned within the tube. RMC is the only manufacturer using this type of dampening bearing at the present time.

Write, wire or phone—tell us your requirements for indicating instruments, and let RMC engineering skill go to work for you. ROCHESTER MFG. CO., 38 Rockwood St., Rochester 10, N. Y.



This special dampening bearing goes one step beyond silicone in the dampening of RMC thermometers. Only RMC uses this *extra* dampening device in addition to silicone and the usual stamped guide bearings. It is a precision machined part, serving several needed dampening functions.

Special bearing *plus* silicone double-dampens RMC thermometers

In RMC bimetal thermometers a specially designed dampening bearing is used just above the bimetal element. This bearing further dampens the shaft, helps to prevent coil unwinding and pointer oscillation, and also serves as a better guide for perfect shaft alignment within the tube. It's the combined use of this dampening bearing *and* silicone that makes RMC thermometers extra resistant to shock and vibration. You get this *only* in RMC industrial thermometers.

RMC

ROCHESTER MANUFACTURING CO., INC.
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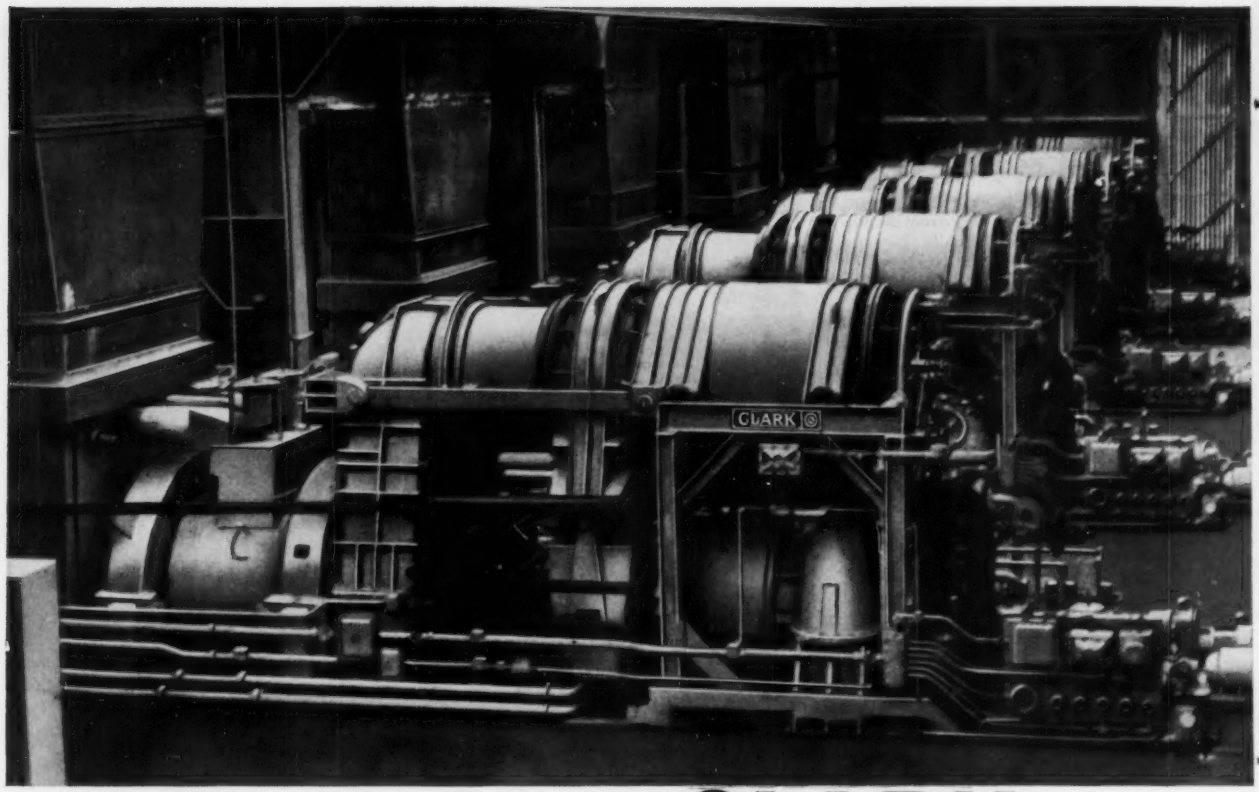
LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

REPRESENTATIVES IN ALL PRINCIPAL CITIES

For more data on advertised products, use Readers' Service Cards, last page.



Five Clark Model 305 Gas Turbines drive Clark vertically-split centrifugal compressors operating in series. The station is highly automated with only two operators required per shift.

CLARK Gas 210,000,000

In the Arabian Desert...

At 'Ain Dar, Saudi Arabia, five Clark Model 305 Gas Turbines are driving Clark Vertically-Split Centrifugal Compressors for the gas injection program of the Arabian American Oil Company.

Surrounded on all sides by the torrid Arabian desert, the turbines and compressors are installed in a pressurized building to keep out wind driven sand. Available fuel for the turbines is sour gas while ambient temperatures soar to unusually high levels.

The 'Ain Dar injection plant draws gas from five gas-oil separator plants at a pressure of 125 psig, compressing it to 2100 psig for injection. Any four of the five series connected, turbine-driven Clark compressors can provide the necessary pressure ratio for injection. Maximum flexibility is achieved by the use of dual shaft gas turbines. An additional Model 302 turbine drives a 5600 KW generator to power the gas-oil separator plants.

Turbines Power Aramco SCFD Gas Injection Plant

Proved dependability, minimum maintenance and the low installation costs experienced by other users of Clark gas turbines were important factors in selecting the turbines and compressors for the 'Ain Dar plant.

The fact that some of the Clark turbines and compressors could be delivered from the Olean plant and the balance from Italy, was also of prime importance to Aramco.

Clark 305 and 302 gas turbines have a standard rating of 8700-9300 bhp. 1220 bhp. models are also available. Consult your Clark representative for your next gas turbine or centrifugal compressor project or write for descriptive literature.

CLARK

CLARK BROS. CO.
OLEAN, N. Y.
One of the Dresser Industries

COMPRESSORS • GAS TURBINES

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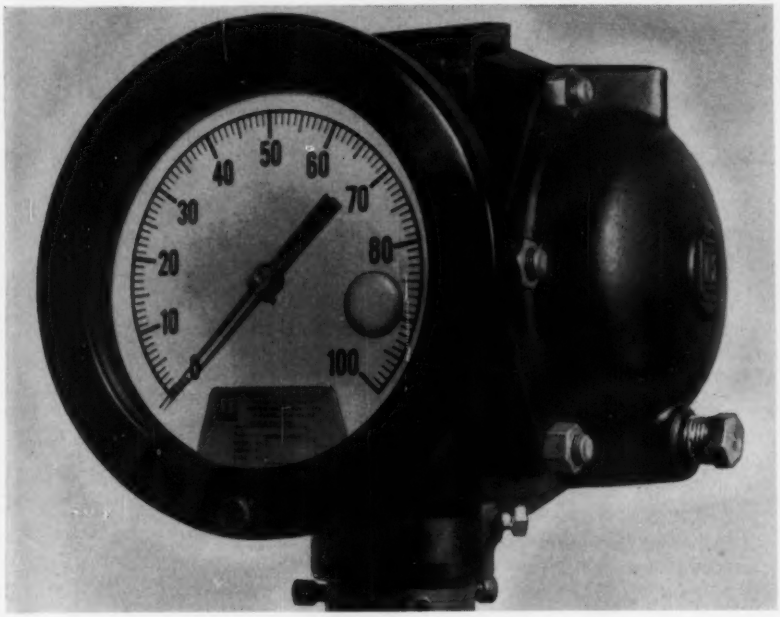
New Equipment & Literature...



Meter Checks Both Flow and Liquid Level

A bellows meter with a 6-inch indicating dial has just been introduced for flow and liquid-level meter applications that do not require recording or transmission.

Typical of applications for which the mercury-less meter is designed are those for indicating steam, air, gas and water volume of industrial processes and side streams or cuts from fractionating towers.

Fifteen differential ranges from 0-20 inches to 0-400 inches of water are available and can be changed in the field by substituting spring assemblies of the desired range.

The meter is equipped with a stainless steel pointer pinion to provide proper meshing and correct indication under all temperature and moisture conditions and a nylon-faced gear sector to assure long life in measuring pulsating flow.

Calibration is made without removing the dial. A micrometer zero adjustment is located on the pointer. A screwdriver-actuated span adjustment is accessible without removing the dial.

Calibrated accuracy is ± 1 percent full scale for ranges of 0-50 inches of water or above and ± 1¼ percent full scale for range below 0-50 inches of water. Standard scale calibrations are 0-100 linear or 0-10 and 0-100 square root with other graduations available upon request.

Other features include: hysteresis ±¾ percent; ambient temperature limits —40° F to + 175° F; compensations for ambient temperatures; linear damping adjustment, and seamless stainless steel bellows. Brown Instruments Div., Minneapolis-Honeywell Regulator Co.

Circle E1 green card, last page

Positive Displacement Pump Used In Blending

The RO-VAR Plenty pump is a rotary design and is completely reversible, as well as infinitely variable in capacity, all at constant drive shaft speed and rotation. Extremely low slip and rugged simplicity of construction are two basic features of this proven design.

A few typical applications include metering of polyvinyl alcohol, blending of Bunker C and diesel oil to produce intermediate marine fuels, blending of asphaltic crude oils, loading-unloading of reduced crudes and Bunker C, and the blending of asphalt cut backs.

The design is particularly well suited for pumping high viscosity ma-

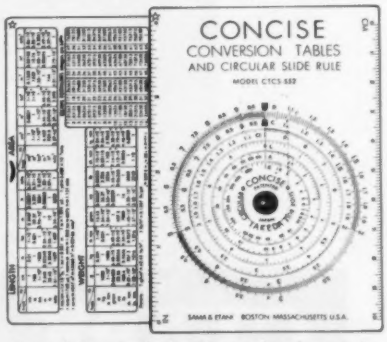
terials such as reduced crude, oxidized asphalt and residuals, as well as polymers, co-polymers and resins. The photograph depicts a Size "H" pump, delivering 1,100 gpm of Bunker C at 150 psig discharge. The pumping rate can be varied from 0 to 1,100 gpm in either forward or reverse flow.

The pump offers a unique concept in variable capacity positive displacement pumps. Eighteen sizes are available, ranging in capacities from 0 to 1 gpm to 0 to 3,000 gpm, with discharge pressures up to 450 psi in single stage. Kearney Industries.

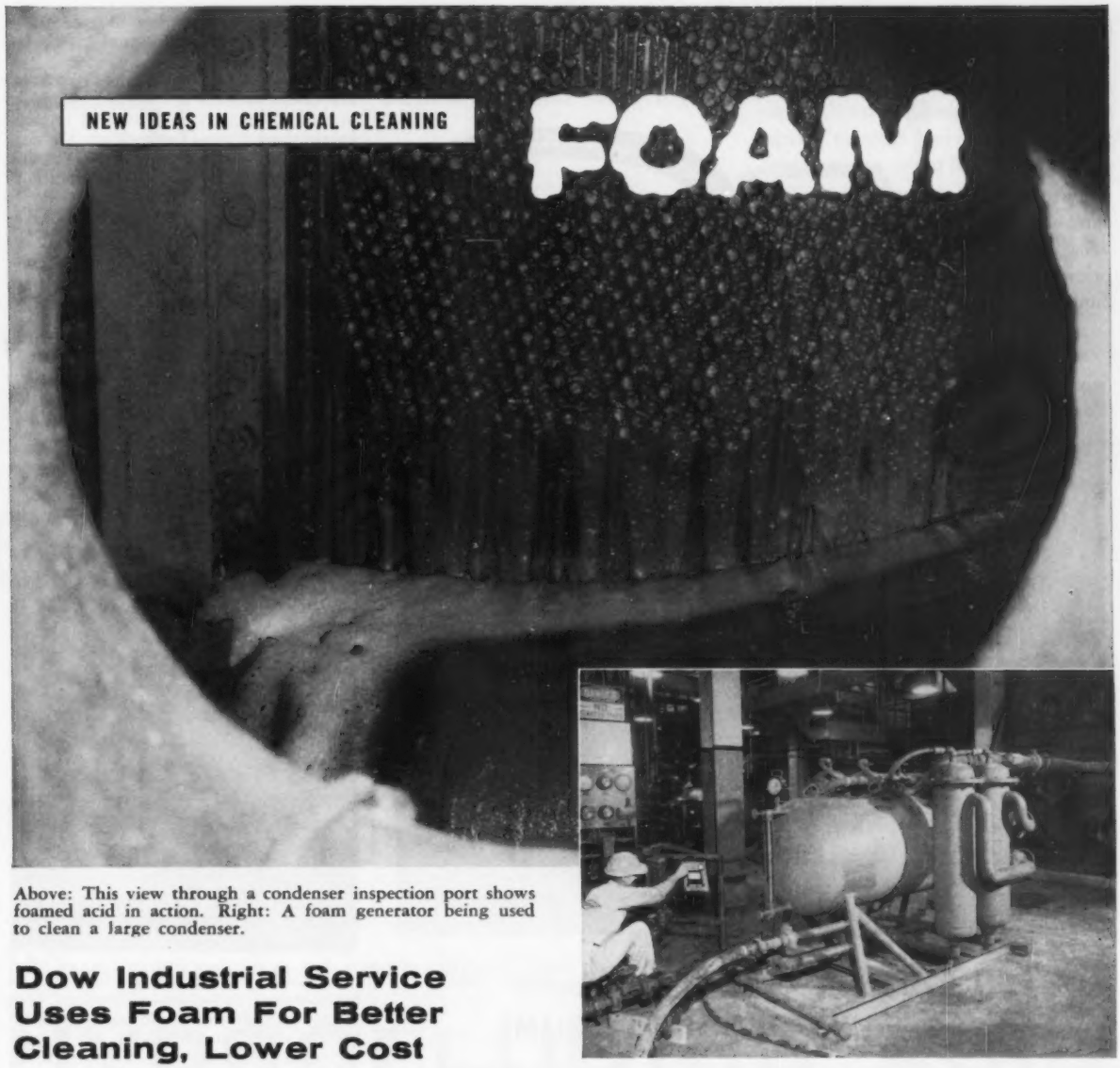
Circle E2 green card, last page

Shirt Pocket Slide Rule Designed For Engineers

The CONCISE Conversion Tables and Circular Slid Rule is an instrument which has been specially de-



signed for technically trained people. The tables contain many important conversion factors, and other useful data, while the circular slide rule has



Above: This view through a condenser inspection port shows foamed acid in action. Right: A foam generator being used to clean a large condenser.

Dow Industrial Service Uses Foam For Better Cleaning, Lower Cost

A newly-developed method of chemical cleaning is helping plant operators reduce the cost of cleaning large-volume vessels.

The new method uses a foaming agent and a special foam generator to expand inhibited acids, water or alkaline solutions to many times their liquid volumes. Foam-to-liquid ratios up to 300-to-one can be attained. For most applications, however, acid is expanded 20 times.

Chemical costs of cleaning large volume vessels with foam instead of liquid are reduced because far less solvent is required.

Reduced solvent requirements mean that disposal or neutralization is simplified.

The light weight of foam makes possible the chemical cleaning of structures where weight is critical.

Foam cleans faster than liquids because solvents can be used at higher concentrations. This helps to reduce both cleaning and outage time.

Certain mechanical benefits result from the use of foamed solvents. The foam provides a scouring action not given by liquids and it carries sloughed materials readily.

Also, foamed solvent fills vessels, pipes and even bent piping as a plug. This eliminates the need for vent connections and reduces the hazard of gases because they are swept out as they are formed.

The foam cleaning technique is just one of many recent developments by Dow Industrial Service to make chemical cleaning faster, safer and less costly.

For engineered recommendations to solve your cleaning problems, contact the field office nearest you, or write Dow Industrial Service, 20575 Center Ridge Road, Cleveland 16, Ohio.

Chemical Cleaning Services for all industry

DOW INDUSTRIAL SERVICE

DIVISION OF THE DOW CHEMICAL COMPANY

DOW

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a 7½ inch circumference. This handy, shirt-pocket-size device is sturdily constructed of polyvinyl chloride plastic, and all scales and tables are engraved.

Detailed information about the contents of the conversion tables, application to company advertising, and price will be sent free upon request. Sama & Etani.

Circle E3 green card, last page

Moulded Back-Up Rings Prevent O-Ring Extrusion

A line of continuous back-up rings for O-ring-in groove installations that not

only increase O-ring life and effectiveness but are quickly and easily installed, and are exceptionally low in cost—up to 50 percent less than normal types, has been developed.

Called Parbaks, these back-up rings are designed with a concave shape to prevent O-ring extrusion and increase lubrication of the O-ring. They are continuous one-piece rings (without spiral or cuts). They thus avoid the possibility of cutting O-rings due to improper installation or worn back-ups. Parker Seal Co.

Circle E4 green card, last page

Lighting Fittings Designed For Dangerous Areas

An entirely new feature is the introduction of two types of weatherproof-vaporproof 200-watt lighting fittings for remotely dangerous areas. These fittings take up to a 200-watt lamp and are of

unique and special design for ease of maintenance and quick re-lamping. One fitting (not shown, single bolt lampglass housing) has an ingenious yet simple action. The top casting has three small wedge shaped ramps which mate up with similar ramps on the lampglass housing and these are engaged and fully tightened by simply tightening up the draw-swing bolt.

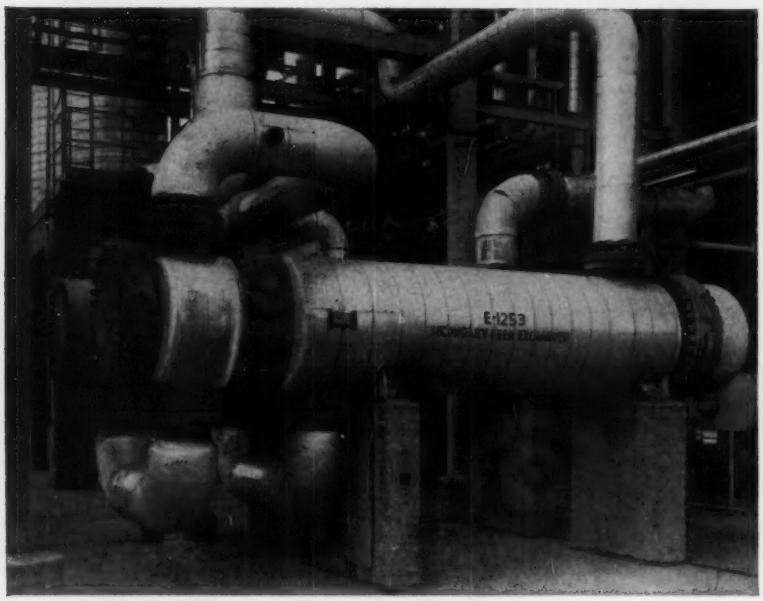
The other fitting (see photo above, toggle action lampglass housing) has a simple yet effective toggle mechanism with adjusting links, whereby maximum pressure is achieved by the final movement of the toggle lever and resilience of the lampglass gasket giving a fully weatherproof and vaporproof sealing. Victor Products (Wallsend) Ltd.

Circle E5 green card, last page

Turbine Bulletin

Bulletin 2001 describes a single-stage, mechanical-drive turbine, centerline-mounted to minimize shaft misalignment due to thermal expansion. The unit, for requirements up to 1,000 hp with inlet pressures up to 875 psig, is adaptable to natural gas expansion. Dean Hill Corp.

Circle E6 green card, last page



EFCO Specialized Experience
Solves Specific HEAT TRANSFER PROBLEMS . . .

Years of experience in engineering and fabricating of heat exchangers for the wide range of temperatures/pressures encountered in refining-petrochemical-natural gasoline plant processes enables EFCO to offer service-proved engineering design and guaranteed job-ratings.

This Shell Oil Company installation, in their Deer Park Refinery, is typical of the many high-pressure, high-temperature alloy exchangers designed and fabricated by EFCO, for platformer feed to effluent exchangers.

EFCO'S FOUR POINT PROGRAM PROVIDES:

- service-proved engineering design
- guaranteed job-ratings
- complete fabricating facilities
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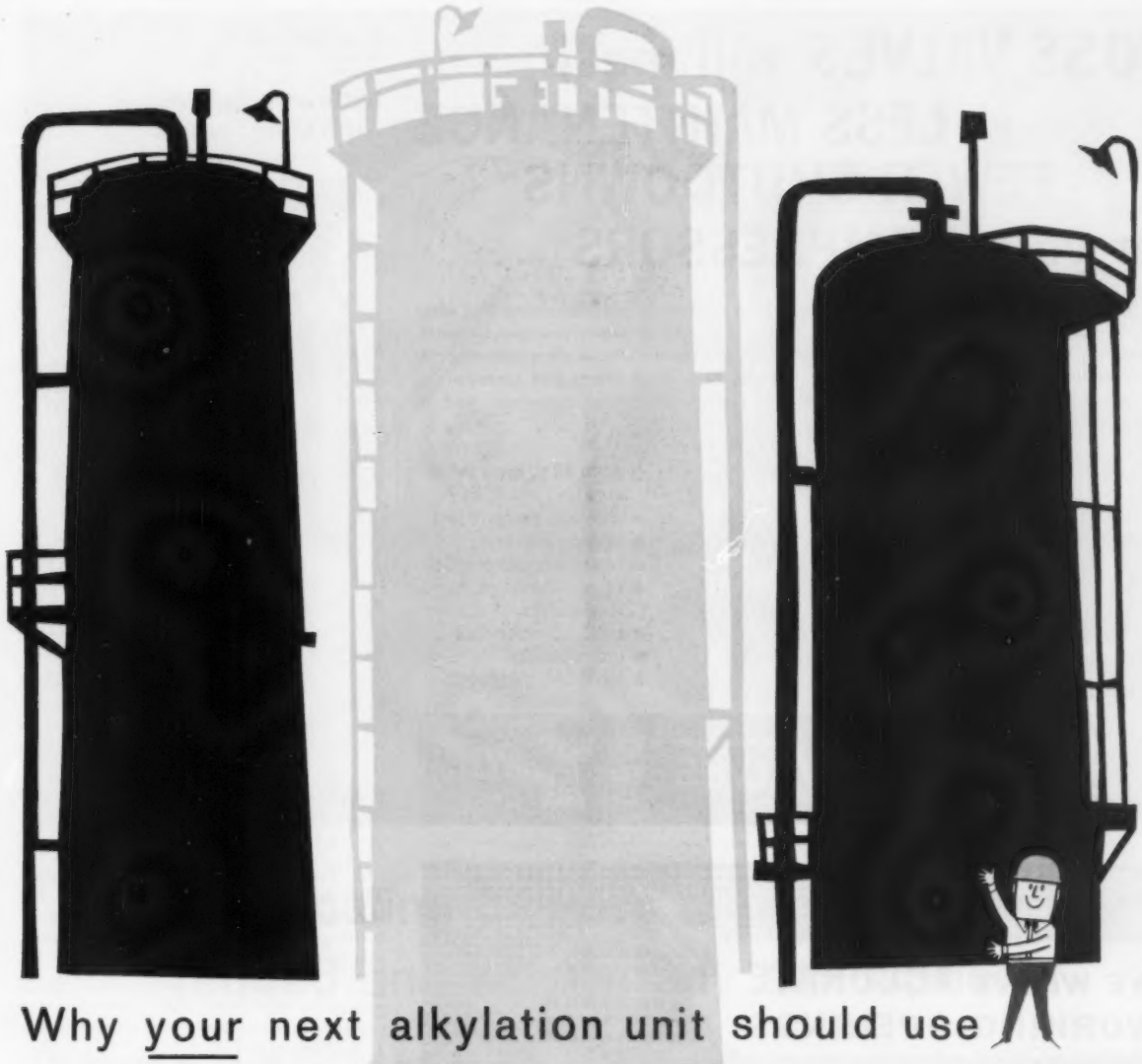
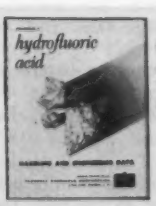


Why your next alkylation unit should use

HYDROFLUORIC ACID

Because anhydrous hydrofluoric acid is easily regenerated, you'll consume less catalyst per barrel of alkylate, lower your catalyst inventory and minimize spent acid problems. AHF lets you cool with water, reduces both initial and operating expense for cooling. And in addition to these economies, AHF gives you shorter reaction time and catalyst settling time, with minimum side reaction products. These advantages have been proved in operating alkylation units across the nation.

To help you cash in on AHF, Pennsalt provides expert, experienced technical aid. We'll show you how to handle, store and use AHF safely and economically . . . advise you on piping, pumps, valves and materials of construction . . . help you with employee training programs. See your Pennsalt representative or write for full information. Industrial Chemicals Division, PENNSALT CHEMICALS CORPORATION, Three Penn Center, Philadelphia 2, Pa.



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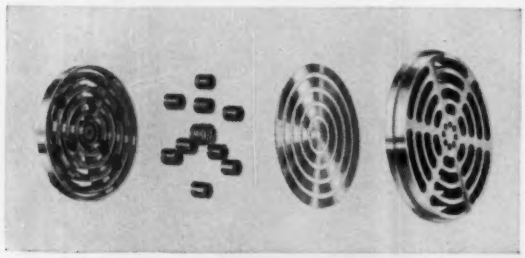
VOSS VALVES will mean LESS MAINTENANCE FEWER SHUTDOWNS for your COMPRESSORS

Voss Valves are made to specification, machined from solid stock (not cast)—using best alloy steels; for corrosion condition—stainless steels, such as 410, 18-8 or non-ferrous alloys—monel, inconel, etc. Plates are machined (not stamped) and ground for precise close tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. Springs of heavy rectangular sections and large diameters add to dependability and safety.



- up to 40% more valve area
- minimum pressure loss
- higher efficiency
- less power consumption
- normal discharge temperature
- quiet, vibration-free
- utmost safety
- lower operating costs

For detailed proposal send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street,
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WE WEAVE ACCURATE "WORKING OPENINGS"

IN WOVEN WIRE SCREEN AND WIRE CLOTH PRODUCTS

Whether you are grinding, sizing, scalping, dewatering or filtering it's the accuracy of the "working opening" that makes the difference in woven wire screen and wire cloth products. We pride ourselves in weaving accurate "working openings", an engineered screening surface to meet your specification.

First, the best metal or alloy is selected—hard enough to withstand the abrasive action—ductile enough not to break under stress. Next, the best wire diameter and crimp are determined. Then we weave wire screen or wire cloth around accurate "working openings" best suited for your screening application.

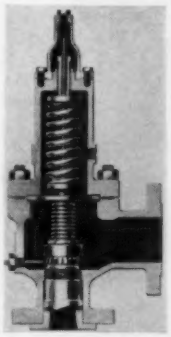
FREE! Write for bulletin 160 giving complete details and facilities.

THE CLEVELAND WIRE CLOTH & MFG. CO.
3571 EAST 78th STREET • CLEVELAND 5, OHIO

Equipment . . .

Bellows Relief Valve For Vapor Service

A new bellows relief valve for vapor service has just been announced. The new valves series DB, are the most modern bellows valves available. Like all bellows valves, they are designed to keep corrosive and viscous fluids away from working parts. They also provide a balancing action against a variable back pressure. In addition, the new series provides bellows valve users with seven unique exclusive features:



1. Saf-T-Alarm to warn of bellows rupture. The indicator can be a self-contained unit or furnished for remote control.

2. Interchangeable with conventional one ring valves.

3. Versatile cap arrangement provides a bolted cap as standard and is interchangeable with a packed cap. Cap contains provision for gagging without taking the valve out of service.

4. Knockout Nozzle that greatly simplifies nozzle replacement.

5. A bellows valve that will not chatter.

6. Two seating surfaces in one disc. The disc will provide longer valve life because it is so designed that merely by turning the damaged seating surface over, you have a new surface.

7. Substantial cost reduction can be gained by the use of PVC trim wherever pressure-temperature conditions allow. J. E. Lonergan Co.

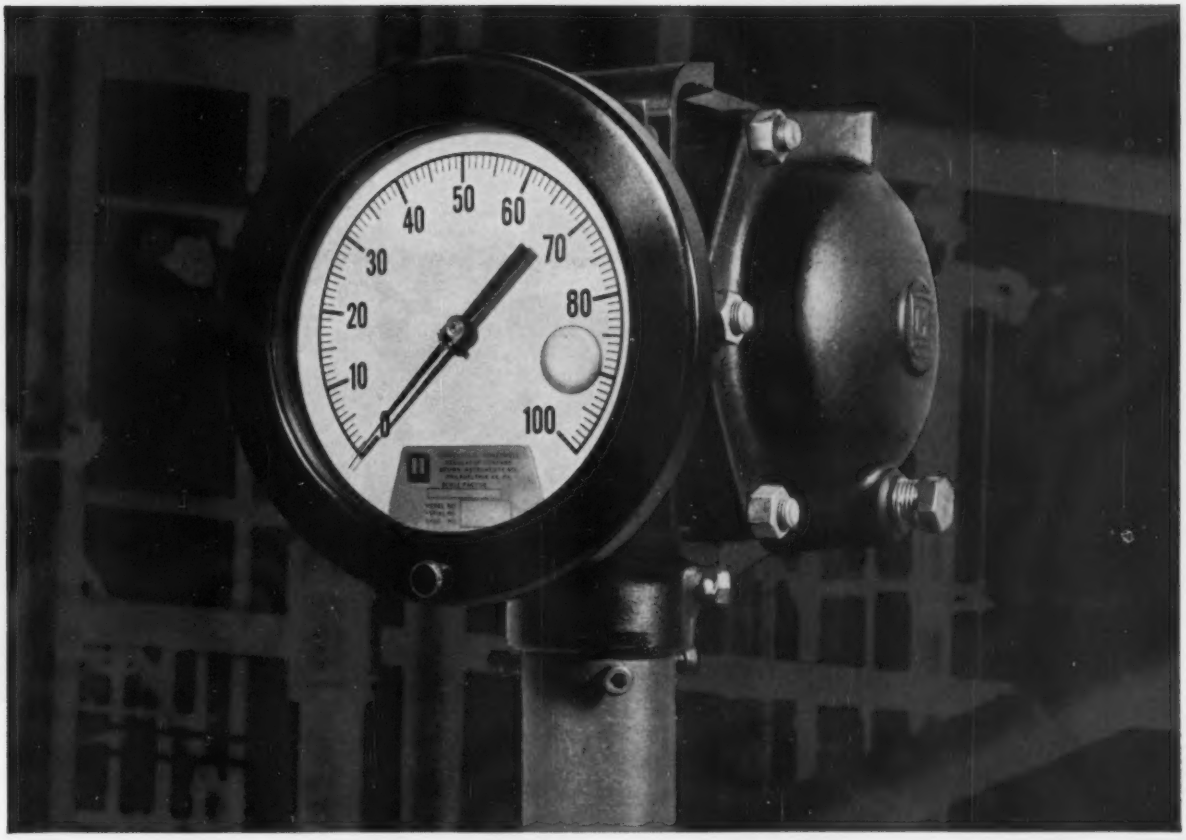
Circle E7 green card, last page

Pocket Receiver Works In Noisy Locations

A high-powered, fully transistorized VHF pocket receiver, providing reliable voice communications even in noisy locations, has just been developed. The new "Handie-Talkie" pocket receiver provides 500 milliwatts audio output, five times the power of previous units. It is available for operation in the 25-54 megacycle and the 144-174 megacycle frequency bands—the standard two-way mobile radio channels.

The small receiver, weighing just over 10 ounces, can be worn in a pocket or clipped to the belt. Both

For more data on advertised products, use Readers' Service Cards, last page.



New indicating bellows meter is accurate, rugged and safe in any atmosphere

Use this new bellows meter for any flow or liquid level application where you want local indication, but don't need recording or transmission. It combines the advantages of the mercuryless bellows meter body with the convenience of an easy-to-read 6-inch dial indicator.

Make pressure connections from either the top or bottom of the meter body, depending on whether you want the meter to be self-venting, draining or purging. And forget corrosion worries; all parts of the bellows exposed to process fluids are of seamless stainless steel construction.

This rugged meter will perform accurately in the toughest service. Two meter bodies are available with pressure ratings of 1000 and 2500 psi, tested at 1500 and 4000 psi respectively. And you can use the meter in hazardous atmospheres because it is self-powered . . . at any ambient temperature between −40° and +250°F. In the indicating movement, a stainless steel pointer pinion and a nylon-faced gear sector assure long life and sustained calibration accuracy of ±1% full scale (ranges of 0-50 inches of water and above) and ±1¼% full scale (ranges below 0-50 inches of water).

This new bellows meter has many other features . . . ease of calibration, simple range change, automatic ambient temperature and static pressure compensation, to name a few. Your nearby Honeywell field engineer can give you complete details. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

75th YEAR
PIONEERING THE FUTURE

Honeywell

First in Control

SINCE 1885

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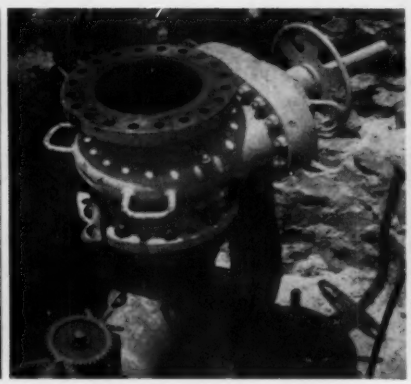
tie-in a 12″ line . . . SAFELY and SIMPLY!



1. attach line stopper fitting . . .

Position the two halves of the line stopper around the pipe and tack weld together.

Rotate fitting to a vertical position and weld to the line. Pressure test the completed installation, checking the welds for leakage.

2. stopping machine valve

Mount the specially designed Mueller Stopping Machine Valve on the line stopper fitting and bolt securely.

This valve is the primary control feature in Mueller No-Blo line stopping operations.

3. drilling the pipe

Mueller CI-36 Drilling Machines make short work of cutting through the existing 12″ line. The cutter is automatically powered by auxiliary air or gasoline engine drive units.

Upon completion of the cut, retract the shell cutter, close the gate valve and remove the drilling machine.

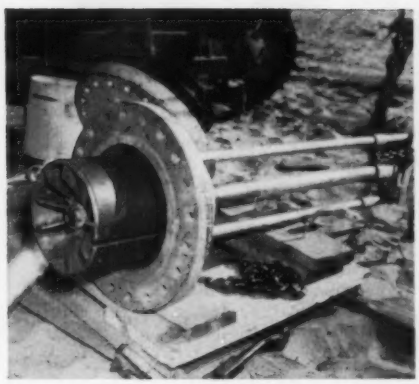
A special ball-detent on the pilot drill securely holds the pipe coupons in the cutter during removal.

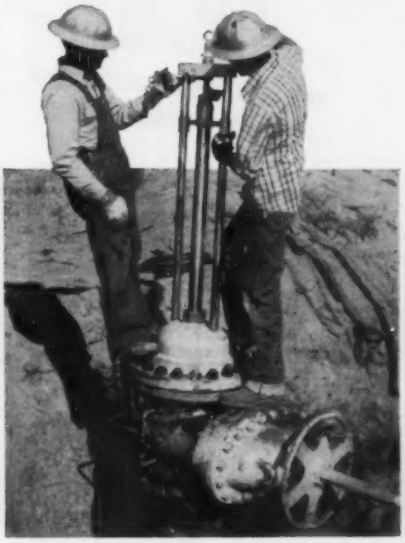
MUELLER® NO-BLO® METHOD

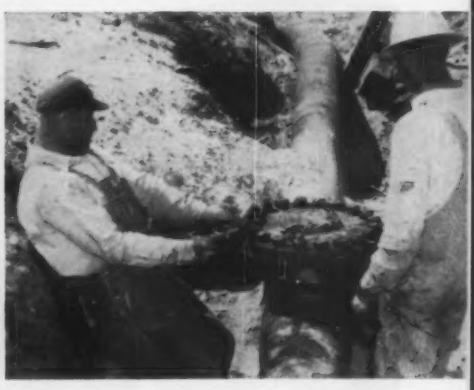
a safe method for isolating line sections!

... *tie-ins* of new or larger lines to existing 10″ and 12″ lines are a simple matter with a Mueller No. 4 Line Stopper Unit. Two stopping machines are used to stop-off the line and completely isolate a short section while the new line is tied-in. An independent bypass line, installed around the two line stoppers and bypassing the isolated section, maintains uninterrupted flow during the entire operation. Tie-ins are completed in absolute safety without loss of line fluid.

Mueller Line Stopper Units and companion Drilling Machines are available for pipe sizes ¾″ through 12″. Contact your Mueller Representative or write direct for complete information.







4. prepare line stopper

Fasten the precision Mueller steel wedge stopper onto the line stopping machine.

The expandable steel stopper will slip into the precision cut made in the line by the CI-36 and shell cutter.

5. insert the stopper

With the upstream and downstream pressure balanced, insert the steel wedge stopper into the pipe and fitting.

The Mueller Line Stopping Machine guides the stopper into position and expands it, forming a solid, leak-proof plug in the line, while the bypass carries the flow.

6. secure completion cap

Upon completion of repairs to the isolated section, remove the steel wedge stopper, activating the new line section, safely and easily.

Remove the Line Stopping Machine and insert the Mueller balanced pressure completion plug into the line stopper fitting.

Bolt the completion cap in place, finishing the stop-off operation.

• *If you have any line relocations, repairs, tie-ins or other operations requiring temporary stop-offs of line fluid, contact Mueller Co. for complete engineering service on your particular application. Ask about Mueller's complete line of No-Blo Methods and Machines.*

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MUELLER CO.
DECATUR, ILL.

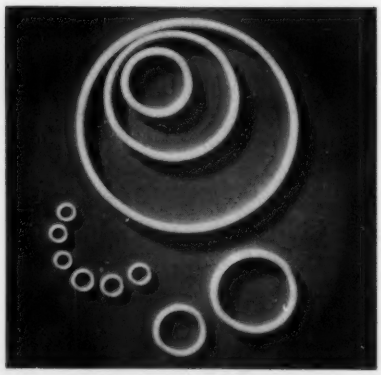
Factories at: Decatur, Chattanooga, Los Angeles
In Canada: Mueller, Limited, Sarnia, Ontario.

volume and squelch can be controlled externally.

The pocket unit operates from either a rechargeable battery or from mercury cells. The rechargeable nickel cadmium supply provides up to 12½ hours operation with each charge. The replaceable mercury cells last up to 125 working hours. Motorola Inc.

Circle E8 green card, last page

O-Rings Now In New SAE Dash-Numbering System



The unique properties of Teflon, including its complete chemical inertness, high heat resistance, and excellent sealing ability have been combined in a new line of O-rings.

Approximately 300 standard sizes are available in the new uniform dash-numbering system for O-rings known as ARP-568, recently adopted by the Society of Automotive Engineers.

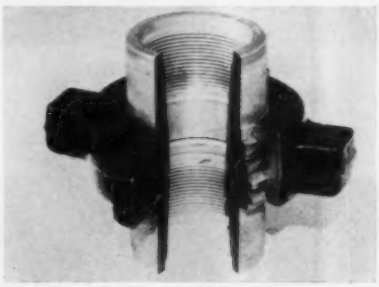
It is believed that the company is the first manufacturer to offer a complete line of TFE O-rings identified by the new ARP-568 series numbers. Old series numbers 6227, 6230 and 6290 which have been used in the O-ring industry for many years, have been incorporated into the new size charts under new ARP numbers, along with approximately 150 new standard sizes. Chicago Gasket Co.

Circle E9 green card, last page

Fast Make-Break Action Featured In 2-Inch Unions

New 4,000 and 6,000-pound working pressure unions with a fast "make-and-break" feature which speeds and simplifies installation and maintenance of pipeline systems, have just been developed.

The unions have a full three-pitch acme thread which turns easily, resists



being clogged by foreign matter, and can be cleaned quickly. In addition to providing easier make-and-break, the acme thread withstands considerably more physical abuse than a conventional V-thread.

Pressure ratings of the new unions were verified under non-shock, cold water pressure (NSCWP) test standards. Both the 6,000 and 4,000-pound units are for 2-inch diameter pipe. Clayton Mark & Co.

Circle E10 green card, last page

Spray Cans For Magnetic Particle Inspection

A new development makes the convenience of magnetic-particle inspection materials available in pressurized spray cans and plastic squeeze bottles. These materials can be used with any of the magnetic particle inspection equipment or test kits already in operation throughout industry.

The ready-to-use materials eliminate previous bulky containers, and the problems of mixing to formula, or filling application devices, and reduce set-up time to inspect complex parts. The new sealed dispensers keep out dust, moisture, and other contamination during storage.

The No. 14M Fluorescent Magnaglo Bath and No. 9BM Magnaflux Bath are

TRINITY STEEL
PROPANE DRYING TOWERS IN FIELD PROCESSING PLANT
Specify "Trinity" For Custom Fabrications
ENGINEERING • PRESSURE VESSELS • ALL STEELS • ALL CODES
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4001 IRVING BLVD.—DALLAS, TEX.—FL 7-3961. LATIN AMERICAN DIVISION: TANQUES DE ACERO TRINITY S. A., CALLE PONIENTE 150, #734, MEXICO 16, D. F. PLANT AND SALES OFFICE. PLANTS IN: DALLAS, TEXAS; FRANCESVILLE, INDIANA; MEXICO CITY, D. F.

YORK Multi-Stage Turbomaster Ideal For Applications Down To 800 cfm

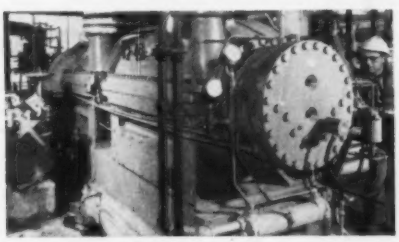
—Offers greater efficiency even for small loads

COMPACT AND ECONOMICAL—On small jobs, Turbomasters offer smoother, pulsation-free operation with virtually no maintenance. On big jobs, two small units can be used, rather than one large machine, to "spare" the system economically.

PRE-ROTATION VANE CAPACITY CONTROL—Standard on all Turbomasters, these vanes provide automatic, continuously variable capacity. This means that compressor capacity stays in direct proportion to load for high system efficiency.

OPERATE BELOW CRITICAL SPEED—Turbomasters up to 6 stages operate well below critical speed. Short, stiff shaft and lightweight aluminum rotors make this possible. Impeller assembly factory-tested at an over speed of 20% or more to insure reliability.

VERSATILE TO MEET YOUR REQUIREMENTS—Up to 8 stages in one casing with choice of casing and rotor materials and sizes, plus side loading and interstage connections to meet exacting requirements. Simple centrifugal design has 400 less parts.



Another YORK Trail Blazer Concept Proved in Action at *Wyandotte Chemicals Co., Geismar, La.*—Two 6-stage 1880 hp turbine driven tandem compressors supply refrigeration for chlorine production. Five suction connections handle 2 loads of condensing chlorine at 2 temperature levels, a water cooling load and 2 stages of refrigerant cooling.

YORK

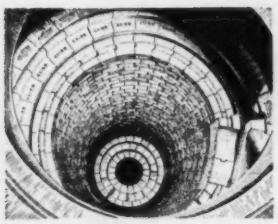
YORK CORP., SUBSIDIARY OF BORG-WARNER CORP., 5605 SOUTH GRANTLEY RD., YORK, PA.

YORK BW DIVISION

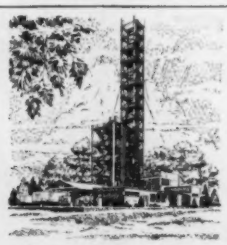
BORG-WARNER RESEARCH & ENGINEERING MAKE IT BETTER

Air Conditioning, Heating, Refrigeration and Ice-Making Equipment • Products for Home, Commercial and Industrial Applications

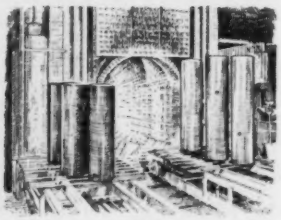
For more data on advertised products, use Readers' Service Cards, last page.



Pebble Heater Linings and Pebbles

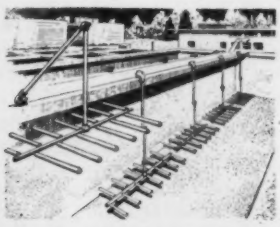


Chemical Reactor Linings

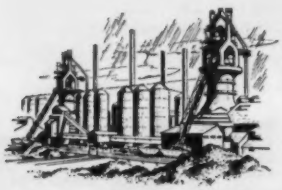


Muffle Plates and Kiln Shapes

Missile and Rocket Ceramics



Porous Media for Sewage Systems



Wear Resistant Linings for sintering

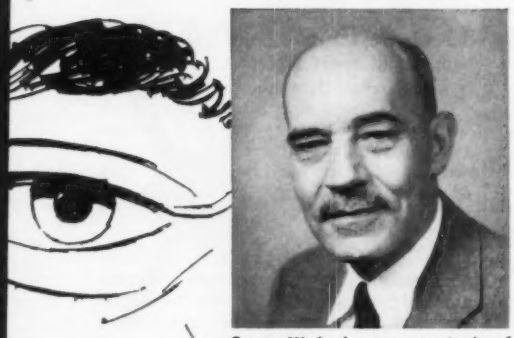
For more data on advertised products, use Readers' Service Cards, last page.

Working with today's imaginative design engineers, Norton Company's "Men with the Facts" are creating exciting new concepts in products and processes. Utilizing the wide variety of physical, chemical and electrical properties of Norton Refractory Materials, they help to solve design problems in products ranging from lightning arrestors to rockets . . . in processes as different as filtration and gas synthesis.

Norton's "Man with the Facts" knows where his company's product can best be applied. Perhaps the high thermal conductivity and high refractoriness of CRYSTOLON* silicon carbide are needed . . . or the excellent chemical stability and abrasion resistance of ALUNDUM* aluminum oxide.

to solve your design problems . . .

NORTON Refractories and the NORTON Man



Curt Weissinger, typical of "Norton Men with the Facts," designed special refractory shapes for a pebble heater to withstand super high temperatures and corrosive conditions. He's also been responsible for successful applications of refractories to reactors, enameling kilns, billet furnaces, missiles and rockets, sewage systems, and other products and processes. Now Supervisor of Norton Refractories Technical Service, Curt has been with the Company for 29 years . . . he's ready to help you in the proper application of Norton Refractory Materials.

Often MAGNORITE* magnesium oxide solves a problem with its high purity and excellent thermal conduction and high electrical resistance. Or, the immunity to oxidation and reduction of zirconium oxide, one of today's highest melting point oxides available in tonnage quantities, may be invaluable.

Find out how Norton Materials and Capabilities can improve *your* product, productive efficiency, and operating economy. Write NORTON COMPANY, Refractories Division, 464 New Bond Street, Worcester 6, Mass.

*Trade-Marks Reg. U. S. Pat. Off. and foreign countries

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REFRACTORIES
Engineered . . . Rx . . . Prescribed

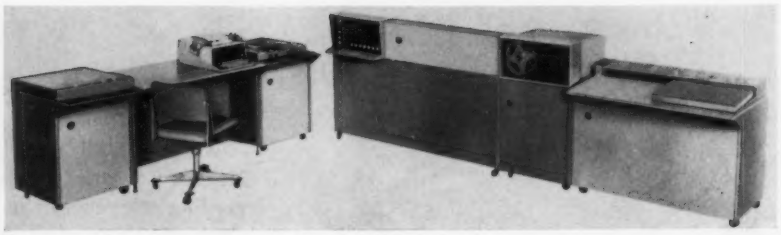
75 years of . . . Making better products
. . . to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

For more data on advertised products, use Readers' Service Cards, last page.

offered in 12-ounce pressure spray cans. The No. 1 Gray Powder is now available in plastic squeeze-bottle dispensers, each containing one full pound of magnetic particles. The perforated top is designed for even powder dispersion with easy hand squeeze. These three basic low-cost test materials have been the most widely used in the earlier forms, and naturally are identical in controlled quality, sensitivity, and high visibility to supply continued full reliability inspection for cracks and similar defects. Magnaflux Corp.

Circle E11 green card, last page



Computer Programs Refinery Operations

Linear programing for refinery operations, plus all the standard accounting applications can be handled by the new, fully-transistorized RPC-9000 Electronic Data Processing System.

The basic system includes: a central processing and control unit which operates in microseconds, performs the calculations, controls the program, and searches the external memory tape; a continuous magnetic tape file for data storage; an input-output tape typewriter system that reads paper tape at 60 characters per second, and punches tape at 30 characters per second.

Information can be entered into the computer from punched paper tape, punched cards, or through the typewriter keyboard. Programing flexibility is provided by 43 commands. No binary conversion is necessary for machine computation.

Internal operating memory consists of nine blocks of magneto-strictive delay lines capable of storing 432 instructions or 72 twelve-character words of data. This may be expanded to approximately 2,000 internally stored instructions, or 328 words. Memory units are compact, simple and easily replaced.

The external data memory is contained on endless loops or magnetic tape. Each tape loop will store up to 1 million alpha-numerical characters, and 100 percent of capacity may be used for data or instructions. Separately stored cartridges of tape expand memory capacity indefinitely.

The RPC-9000 is available on lease, lease with option to purchase, or purchase. Monthly rental for the basic system is approximately $2,500. Installation, operational start-up (including personnel training) and follow-up services are included. Royal McBee Corp.

Circle E12 green card, last page

Tube Fitting Catalog

A new 44-page catalog which contains a wealth of technical data and fully describes the complete Hi-Seal butt-joint fitting line is available. The new catalog, industry's most complete engineering file on any single fitting, is packed full of vital technical data which is of value to any engineer connected with tube circuitry.

It contains more than 250 additional styles and sizes, and the first printed material on Braze-Seal fittings for extra high pressure and temperature.

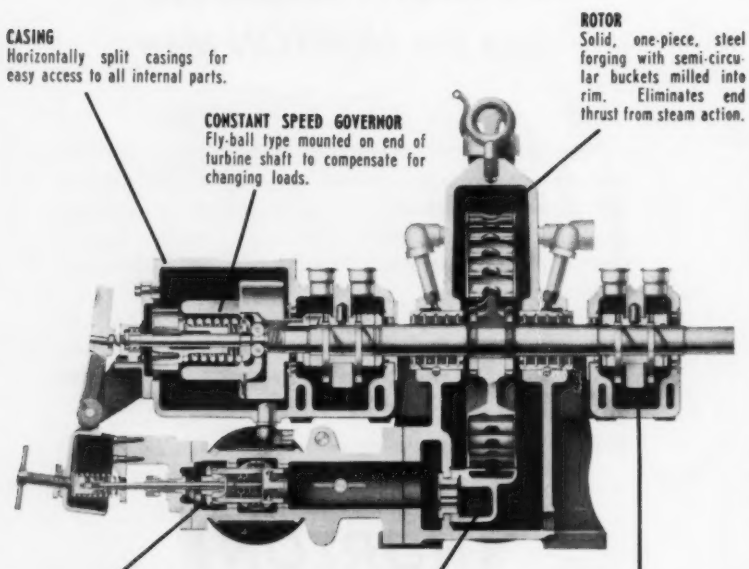
There are sections on pressure, vacuum, temperature, vibration, corrosion resistance, port seals, flow and velocity characteristics along with laboratory reports and complete assembly instructions.

Styles, sizes and materials of Hi-Seal stock items are listed in an easy-to-fol-

Whiton

PRECISION ENGINEERED STEAM TURBINES

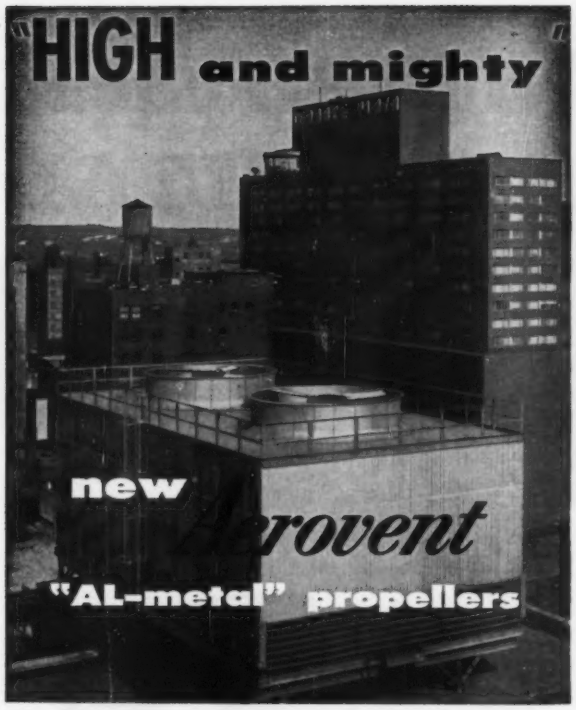
For almost 50 years, Whiton has combined experience, workmanship and **precision engineering** in building high quality, reliable steam turbines for all types of power and drive applications. Whiton horizontal, helical-flow, single stage turbines are available in 8 wheel sizes. Axial-flow, Curtis-blade turbines are also available. Write for complete data on Whiton's horizontal and vertical turbines.


CASING
Horizontally split casings for easy access to all internal parts.
CONSTANT SPEED GOVERNOR
Fly-ball type mounted on end of turbine shaft to compensate for changing loads.
ROTOR
Solid, one-piece, steel forging with semi-circular buckets milled into rim. Eliminates end thrust from steam action.
GOVERNOR THROTTLING VALVE
Double-seated, balanced V-ported. Admits steam to assure stability control as load varies.
NOZZLE BLOCK AND REVERSING CHAMBER
One-piece unit. 2, 3, or 4 redirecting buckets as required for maximum efficiency.
LUBRICATION
Water cooled oil ring lubrication.

MAXIMUM OPERATING SPECIFICATIONS

POWER	to 1200 HP
SPEED	to 8500 RPM
STEAM PRESSURE	to 1250 PSIG
STEAM TEMPERATURE	to 1050° FTT

THE WHITON MACHINE COMPANY
NEW LONDON, CONNECTICUT



move mountains - of AIR!
in towers and exchangers

- Sizes 14' to 18'
- 4 or 6 blades

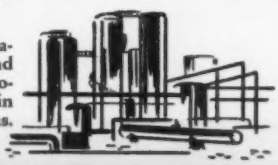
Developed originally for the petroleum industry, Aerovent Large-Diameter "Al-metal" Propellers, constructed of tough, durable aluminum alloy, move great quantities of air at high velocities, in heat exchangers and cooling towers. Pictured above are two 4-blade, 16-ft. propellers in a cooling tower installation. These mighty propellers, with adjustable-pitch "Macheta" Airfoil blades, are job-engineered to individual specifications.

Write for free Bulletin 510

DESIGNED FOR DEPENDABLE OPERATION!

Endurance tests, conducted at *3 times* normal loading prove the ability of these new large-diameter propellers to withstand severe punishment. Heavy-duty cast steel hubs offer maximum resistance to stresses. Angle settings for each operating requirement, and appropriate alternate settings, assure accurate pitch for any predetermined performance which may be required. 54" to 144" now available in Adjustable Pitch Models.

REFINERIES, pumping stations, industrial plants and commercial buildings use Aerovent "Al-metal" Propellers in major air-moving applications.



Aerovent FAN COMPANY, INC.
LARGE PROPELLER DIVISION
304 Wright Bldg.
TULSA 3, OKLA.
Main Office and Factory
PIQUA, OHIO

Now! More Dead Weeds and Brush per Dollar

with UROX® WEED KILLER

One Application Gives 8 to 18 Month Control!

Here's the weed killer you can *positively depend on* to wipe out weeds and brush faster, easier, at lower cost and for a longer time than you ever thought possible. Urox weed killer effectively handles weed killing jobs along pipelines, on tank farms, around refineries and pumping stations, where weeds and brush are a constant fire hazard. In all these places, *just one application of Urox weed killer will remain effective for as long as 8 to 18 months!*

Longer lasting! Saves time and money! Urox weed killer has a cumulative effect on weeds and brush. Its herbicidal action can thus be extended from one year to the next with light booster doses. As smaller amounts are used over a period of time, you realize substantial savings.

Easy to use! *Liquid Urox* weed killer is ideal for spraying large overgrown areas. It won't clog spray nozzles or strainers! Won't precipitate out in the tank! Stays in solution perfectly! *Granular Urox* weed killer is the convenient inexpensive way to treat small weed-infested areas. Can be applied easily with any mechanical or hand-operated spreader.

New Urab* weed killer kills deep-rooted brush and weed trees! If you have problems with tough, deep-rooted weeds, brush or weed trees, *New Urab Weed Killer* is just what you're looking for. Urab weed killer actually *penetrates soil* to kill deep roots. Does what no other herbicide can! Supplied in liquid and granular forms.

*Trademark of Allied Chemical Corporation

Get the whole story! Mail this coupon!

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GENERAL CHEMICAL DIVISION
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Weed Killer Dept. PR-50
GENERAL CHEMICAL DIVISION
Allied Chemical Corporation
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☐ Please send me more information about General Chemical's amazing new herbicides, Urox and Urab.
☐ Please have representative phone for appointment.

Name_____
Title_____
Company_____
Address_____
City_____ Zone_____ State_____

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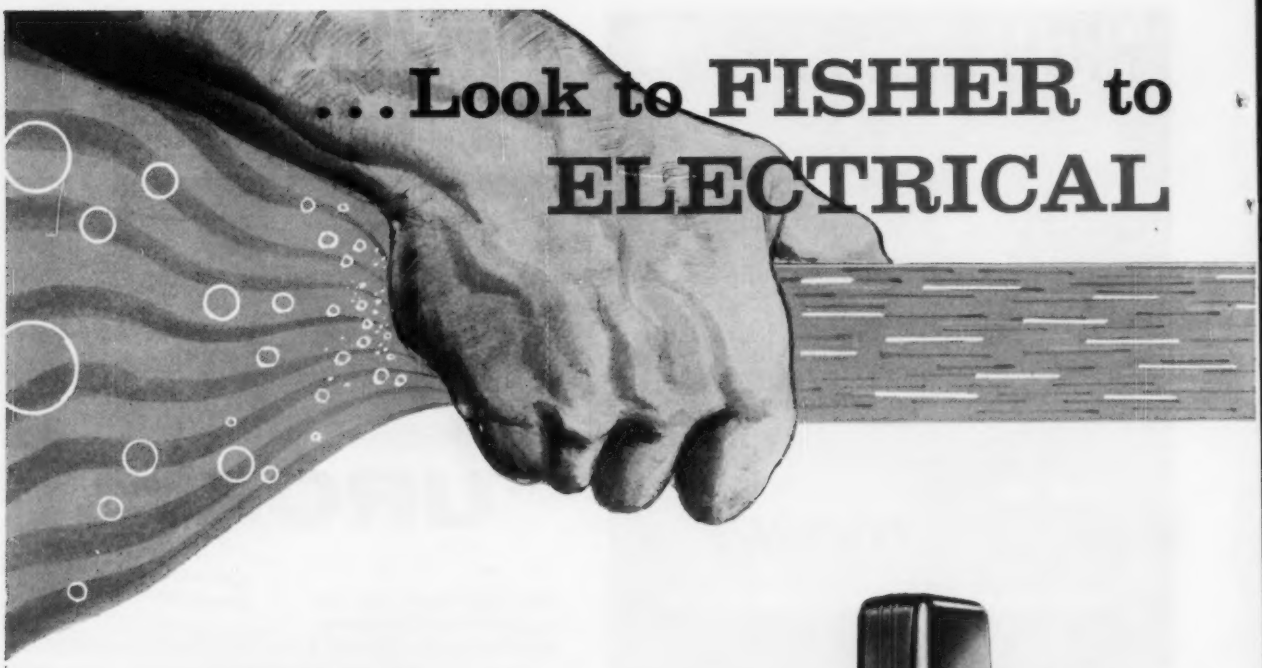
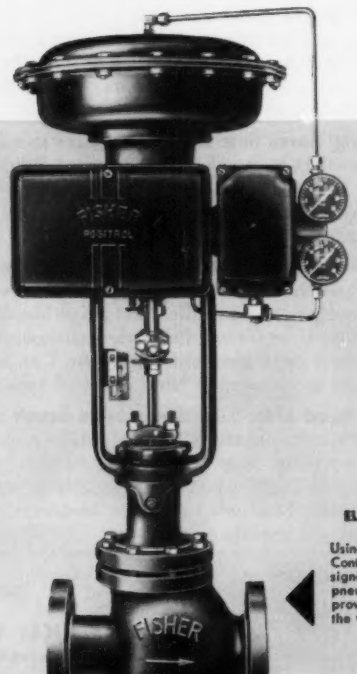
...Look to FISHER to ELECTRICAL





THE PNEUMATIC OPERATED PISTON "P.O.P." WITH ELECTRO-PNEUMATIC TRANSDUCER

The compactness, speed and power available from the FISHER Series 470 P.O.P. is readily made available in electrical control systems with the use of the yoke mounted Type 545 Electro-Pneumatic Transducer.

Input Current: 1 to 5 ma, 4 to 20 ma, 10 to 50 ma, d.c.

Linearity—1% of Full Range

Resolution Sensitivity—Less than 0.1% of Input Range.

THE ELECTRO-PNEUMATIC POSITIONER "E-POSITROL"

Using a conventional Fisher diaphragm Control Valve, the E-Positrol receives a Ma signal and translates this to a proportional pneumatic signal to a positioner which provides the speed and power to operate the valve.

Input Current: 1-5 ma; 4 to 20 ma, 10 to 50 ma D.C.

Linearity—1% of full scale.

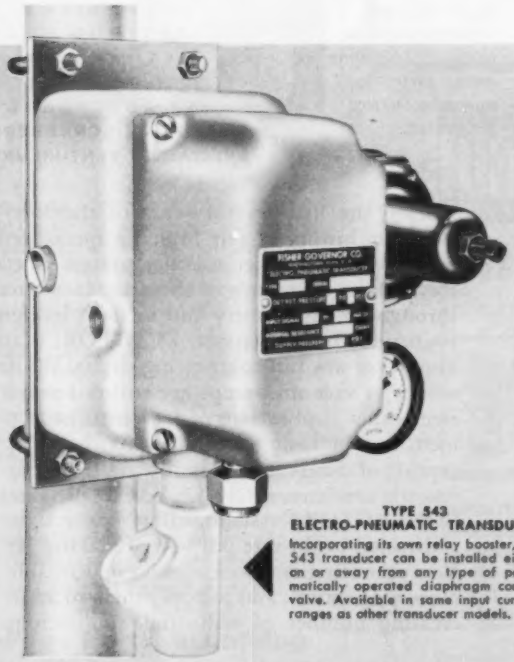
Resolution Sensitivity—0.1% of input range.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY...

supply the muscles for your CONTROL SYSTEMS

The old adage, "a chain is as strong as its weakest link" can be equally applied to the "muscle" or more correctly the final control element on any control loop. The importance of a control valve in an electronic system should never be considered lightly and that is why you should look to Fisher for assurance in furnishing dependable and accurate control valves for your electrical or electronic system.

Described below are three types of actuators that offer an exceptionally practical and economical approach for control valves in electrical control loops.



TYPE 543
ELECTRO-PNEUMATIC TRANSDUCER

Incorporating its own relay booster, the 543 transducer can be installed either on or away from any type of pneumatically operated diaphragm control valve. Available in same input current ranges as other transducer models.

THE TYPE 350
ELECTRO-HYDRAULIC ACTUATOR

In electrical control systems where air is not available or desirable, the Fisher Electro-Hydraulic Actuator provides all the necessary requirements for a dependable and accurate control valve.

Maximum Stem Thrust..2000 pounds
Stroking Speed.....0.37 in./sec.
Resolution Sensitivity...less than 0.05%

FISHER® Controls
SINCE 1880

FISHER GOVERNOR COMPANY
Marshalltown, Iowa / Woodstock, Ontario / London, England
BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIPMENT CO., CORAOPOLIS, PA.

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over multiple source buying of YOUR laboratory needs

Make Curtin your one reliable source for laboratory supplies. Complete stocks of quality laboratory equipment are maintained for immediate delivery at supply points strategically located in all major refining areas. Technical and Repair Services are readily available all the time to help with your specific problems. Call Curtin on your next laboratory order and get "everything at one source."

W. H. CURTIN & CO.

DOMESTIC EXPORT • CURTIN PETROLEUM TESTING EQUIPMENT

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ENGINEERING PERSPECTIVE THROUGH A

VENTURI

Venturi tubes were first used for measuring fluid flow. While this application has increased substantially, the use of the Venturi in important unit process operations has increased even more. A Jet-Venturi combination is literally the heart of many important manufacturing processes.

JET REFRIGERATION
JET COMPRESSORS
JET CONDENSERS
JET HEATERS
JET PUMPS
JET MIXERS
JET REACTORS
JET ABSORBERS
JET FUME SCRUBBERS
SPECIAL JET VENTURI UNITS

During the first several years of the forty-two year history of our firm, we specialized entirely on steam jet vacuum pumps (ejectors). Many thousands of these are in service throughout the country and in most foreign countries. Our tradename, EVACTOR, is an important word in engineering circles. While steam jet vacuum pumps are still our major item, other applications of Jet-Venturi equipment are increasing constantly. With the exception of closely related products such as barometric condensers, CHILL-VACTORS, and CONVACTOR* systems, all of our activity is directed to the one purpose of making Jet-Venturi units more efficient, more dependable, more economical, and to apply them to an increasing number of industrial applications.

* The CONVACTOR is a dual condensing system for economic and efficient recovery of high boiling components from water vapor.

CROLL-REYNOLDS

Croll-Reynolds CO., INC.

Main Office: 751 Central Avenue, Westfield, N. J.

New York Office: 17 John Street, N. Y. 38, N. Y.

Chill-VACTORS® • Steam-Jet EVACTORS® • Aqua-VACTORS® • Fume Scrubbers • Special Jet Apparatus

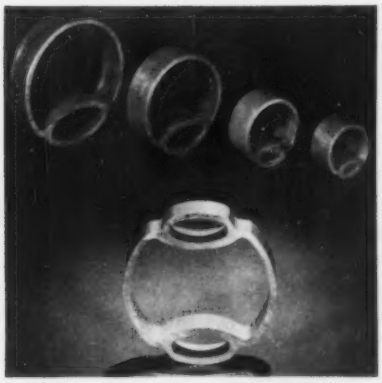
Equipment . . .

low manner with complete dimension data on each type. Listing includes assorted fittings, valves, hose couplings and the special filter tee for continuous gas analyzation in chemical plants, refineries, hydraulic work and pneumatic systems. The Imperial Brass Mfg. Co.

Circle E13 green card, last page

Aluminum Pipe With Dual Built-In Return Passages

A new tubular product, with built-in channels to simplify and reduce the cost of recirculating heating-fluids required in piping systems has been announced. Known as Duotrace, the uniquely designed pipe is shown here (foreground)



with Unitrace, the original steam-traced piping introduced by Alcoa. The one-piece, extruded Duotract section contains two integral channels flanking a large, product-carrying pipe area. The heating medium travels through one small oval passageway, maintaining temperature of bulk material in the product line to insure a free flow. At a terminal, the fluid is reheated, if necessary, prior to being returned through the second channel. The new product was designed specifically to eliminate extra piping, now used to return such media as hot water, oil and commercial preparations to a source for recirculation. Duotrace is available in 2, 3 and 4-inch pipe sizes. It also can be used in applications requiring the circulation of refrigerants, and for conveying several products in one piping system. Aluminum Co. of America.

Circle E14 green card, last page

84-Page Electrical Catalog

The 1960 edition of the Buy Log has been released. The 84-page Buy Log covers low-voltage distribution equipment.

The manual is designed to serve as a condensed buying catalog for service entrance equipment, light and heavy-duty safety switches, tumbler and open-knife switches, hinged wireway, circuit breakers, switchboards, motor control centers, sectional distribution centers, and all types of panelboards and busways.

It is designed so that application, selec-

CONTROL ENGINEERS

RW-300 COMPUTER SYSTEMS FOR PROCESS CONTROL

The Thompson-Ramo-Wooldridge Products Company is seeking electrical or mechanical engineers with training or experience in feedback control system analysis, analog or digital computers, and instrumentation. Staff members at TRW Products work in small teams designing and evaluating RW-300 computer control systems for the process industries. Experience in the petroleum refining, chemical, steel, or electric power industries is particularly desirable. Applicants with advanced degrees are preferred. Those interested are invited to write:

Dr. Thomas M. Stout, Process Analysis Department Manager

THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS COMPANY

a division of Thompson Ramo Wooldridge Inc.

202 North Canon Drive • Beverly Hills, California

INSTRUMENT DAVIS DIVISION

Gas Analysis Instrumentation

Combustible Gas Detector Systems. Continuous Plant & Work Area Control. **Bulletin 11-36**

Parts Per Million Analyzers — For measurement of toxic gases and vapors. **Bulletin 11-70**

Thermal Conductivity Gas Analyzers. Gas Purity and Plant Process Control. **Bulletin 11-17**

Continuous Oxygen Analyzers. Systems for analyzing and recording Oxygen content of process gases. **Bulletin 11-40**

CHROMA-MATIC Process Stream Analyzers. High speed Chromatography units for Plant Stream Monitoring and Process Control. **Bulletin CM 1-59**

DAVIS INSTRUMENTS
164 Halleck Street, Newark 4, N. J.
Please send Bulletin No(s).
NAME_____
COMPANY_____
ADDRESS_____
CITY_____ STATE_____

For more data on advertised products, use Readers' Service Cards, last page.

tion, pricing and ordering information can be found quickly and easily. Among the many features of the Buy Log are: Selector charts for each type of product, pictorial descriptions, consolidated pricing tables, and a cross-referenced catalog number index.

Also included are ratings, weights, dimensions, standard package quantities, ordering directions and several pages of general application information. General Electric Co.

Circle E15 green card, last page

Polyethylene-Coated Plugs Stop Plug Valve Freezing

Polyethylene-coated plugs for use with saran-lined plug valves are being manufactured.

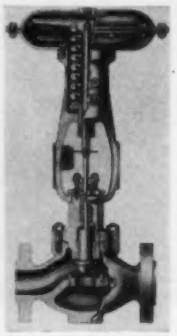
The linear polyethylene plugs eliminate the "freezing" that sometimes occurs when saran plugs are used with saran-lined pipe. This "freezing" occurs when lubrication fails. When the saran surfaces get dry it is almost impossible to move the plug for line operation.

The new plugs are suitable for many installations where polyethylene has adequate chemical resistance. They are available in eight sizes ranging from 1 to 6 inches. The Dow Chemical Co.

Circle E16 green card, last page

New Control Valve Series

A new 20000 series of single-seated control valves has just been announced. Features include high capacity, ability to handle high pressures and pressure drops and a wide selection of reduced capacity trim.



The design incorporates a top guided, unrestricted seat-ring area with body and plug contours providing greater capacity than most top-and-bottom-guided double seated valves of comparable sizes. In addition, high capacity is attained with minimum seat-ring areas, resulting in less unbalance force, permitting higher pressure drops. Heavy guiding throughout full stroke results in a minimum of unsupported plug length and allows high-pressure and high-pressure-drop applications without lateral vibration. Versatility of this new series is emphasized by a wide selection of reduced capacity trim which is interchangeable in comparable valve sizes and ratings. This is desirable for applications where velocity due to high drop is a consideration or where future requirements for larger capacity may be present. Mason-Neilan, Div., Worthington Corp.

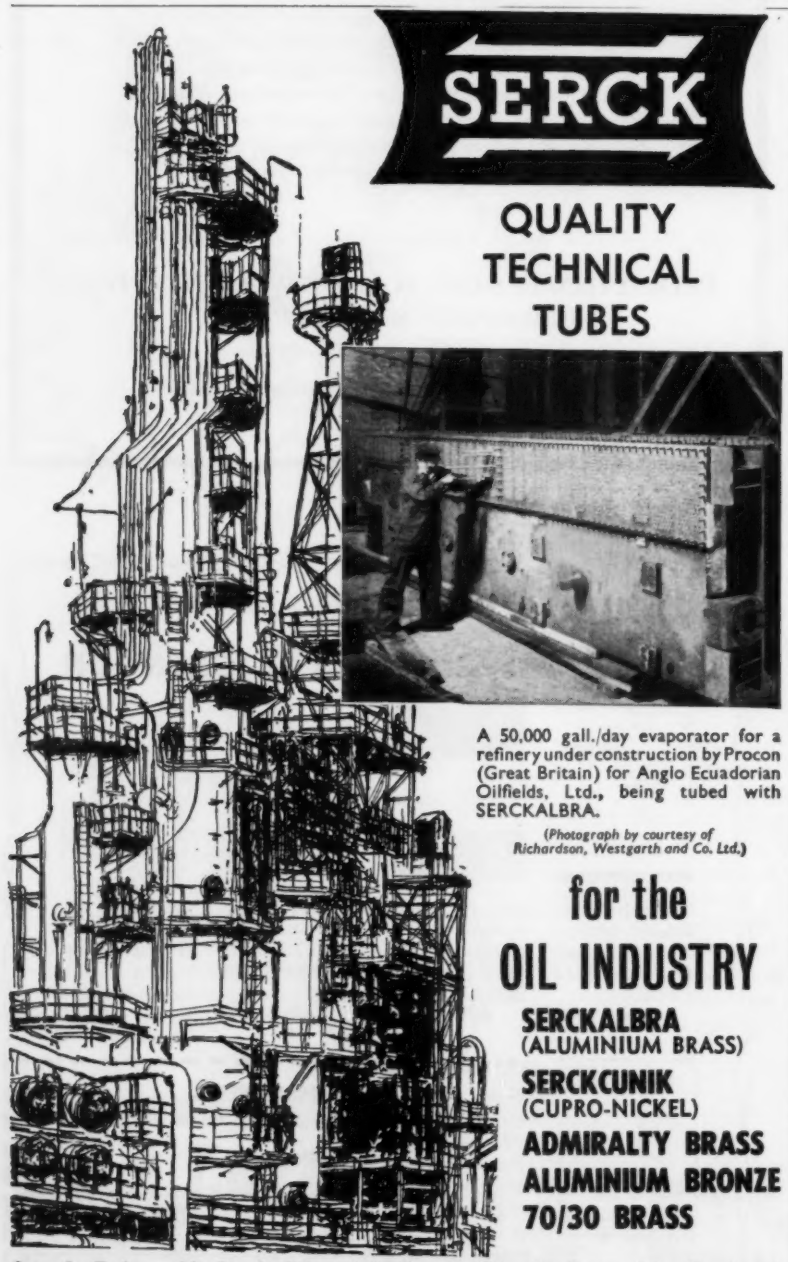
Circle E17 green card, last page

64-Page Alloy Steel Book Aids In Casting Selection

A new booklet, "Heat Resistant Castings . . . Corrosion Resistant Castings . . . Their Engineering Properties and Applications", has just been issued.

The fully-illustrated 64-page booklet is designed as an aid to those interested in stainless steel and high-alloy casting selection, design and production. It offers a comprehensive picture of all types of stainless steel and high-alloy heat and corrosion-resistant castings and their applications.

These alloys are used under the most severe corrosive conditions and with temperatures up to 2000° F and higher. To



SERCK

QUALITY TECHNICAL TUBES

A 50,000 gall./day evaporator for a refinery under construction by Procon (Great Britain) for Anglo Ecuadorian Oilfields, Ltd., being tubed with SERCKALBRA.

(Photograph by courtesy of Richardson, Westgarth and Co. Ltd.)

for the OIL INDUSTRY

SERCKALBRA (ALUMINIUM BRASS)

SERCKCUNIK (CUPRO-NICKEL)

ADMIRALTY BRASS

ALUMINIUM BRONZE

70/30 BRASS

Serck Tubes Limited, Warwick Road, Birmingham 11, England

A member of the Serck Group.

HALF a MAN

is not enough!

human interests must balance technical efficiency

Consistent improvement has been made over the years in the quality and service of Western Heat Exchangers, as well as in providing more effective solutions to the heat transfer problems of our customers by recognizing the need for keener insight into the personalities and problems of the **people** with whom we deal — our suppliers, customers, employees and associates.

Every advance we have made in design, mechanics, metallurgy and fabrication is the product of **engineers** — not engineering — **creative individuals** whose technical proficiency is balanced by their understanding of the individual problems of the people we serve and with whom we work.

Increased efficiency, longer life, less maintenance, lower costs — these are the benefits that accrue to Western customers as a result of this philosophy of business. **We could do no less for you, given the opportunity.**

WESTERN'S STAKE IN YOUR FUTURE

. . . is in the hands of men — *whole* men — whose professional acumen is matched by an insight to the human relationships in engineering. This vital need is more completely exposed in the latest of Western's "engineer-advancement" messages, the first few lines of which are shown at right. A complete pamphlet on the subject is available to you, singly or in quantity, upon request.

One of a series appearing in OIL & GAS JOURNAL, CHEMICAL ENGINEERING, PETROLEUM REFINER, REFINING ENGINEER, CHEMICAL ENGINEERING PROGRESS.

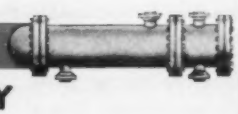
Facts-of-Life for successful engineers must include attitude, self-appraisal, vision, understanding, respect, relaxation and "happiness"

Achieving "success" and/or "happiness" in your professional and personal future won't just "happen," regardless of how diligently you apply yourself to your daily tasks, unless your efforts are coordinated along specific paths of endeavor. Your life as an engineer must be counterbalanced by your life as an individual — because "engineers ARE human," despite comment to the contrary.

serving the growth of the process industry

WESTERN

HEAT EXCHANGERS



WESTERN SUPPLY COMPANY

P.O. Box 1888 – Tulsa, Oklahoma

For more data on advertised products, use Readers' Service Cards, last page.

ensure easy reference, the booklet is divided into three sections: Heat-Resistant Alloys, Corrosion-Resistant Alloys and Fabrication Data. Typical headings include How To Select the Proper Casting Alloy, High-Temperature Mechanical Properties, Heat-Resistant Alloy Casting Design, Corrosive Attack, Groups of Corrosion-Resistant Alloy Castings, Corrosion Data, Machining, and Welding. This material is supplemented by 13 tables of technical information on heat and corrosion-resistant castings. The International Nickel Co., Inc.

Circle E18 green card, last page

Catalog Contains Thirty Insulations By New Firm

The first catalog published since the merger of Baldwin-Hill Co. with Ehret Magnesia Manufacturing Corp., contains the full line of more than 30 industrial insulations manufactured by the new corporation. Properties and specifications of the complete line of heat and cold insulations for service from sub-zero up to 1,900° F are presented.

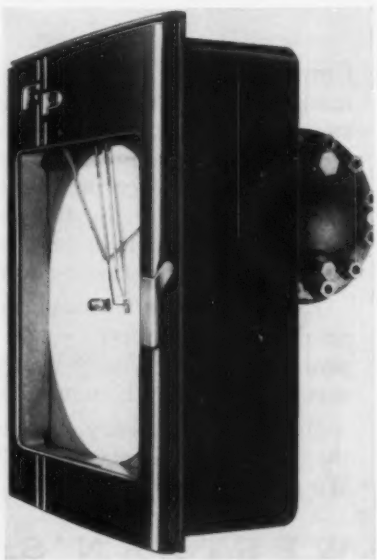
Spun mineral wool, calcium silicate, and 85 percent Magnesia products in block, blanket, felt, fill, cement, and pipe-insulation forms are fully described and illustrated in the 24-page, two-color booklet. Thermal conductivities and tables of recommended thicknesses are given for each product for appropriate temperature ranges. Illustrated application instructions are also included.

A selection chart, which indicates the temperature range of all included types of material, is presented along with illustrations of typical installations. Baldwin-Ehret-Hill, Inc.

Circle E19 green card, last page

Flow And Liquid Level Measured by Flowmeter

A new metallic Bellows Flowmeter has just been introduced. This differential-pressure measuring device can be used for both flow and liquid-level applications. It is accurate within ½ of 1 percent using no mercury, seal-pots, purges or stuffing boxes. The meter body is completely self-draining and self-venting and is rated at 2,000 and 5,000 psig in steel and stainless steel. The flowmeter has ranges from 0-20 to 0-300 inches of water and may be changed by a simple exchange of the range spring assemblies.



This indicating and/or recording instrument can be equipped with a controller, totalizer, or with a pneumatic or electric transmitter. Additional pressure and temperature indicators or pens are available. Fischer & Porter Co.

Circle E20 green card, last page

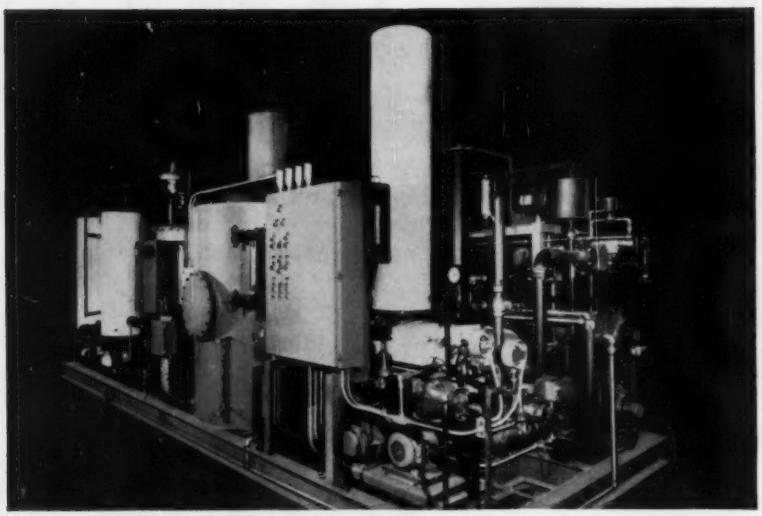
Pneumatic Valve Bulletin

A new bulletin covering a complete line of pneumatically actuated Saunders patent-type valves, has ben issued. The bulletin is a well illustrated 8-page booklet which gives construction details, operating characteristics and specifications of the valves. Included is a section on valve sizing and flow co-efficients which aid in the proper selection of Saunders valves.

The bulletin shows a complete line of close-coupled valve actuators including

gas Atmospheres, inc

THE NATION'S LARGEST MANUFACTURER OF PACKAGED GAS GENERATOR SYSTEMS



Performance Plus floor-saving compactness, trouble-free maintenance and "minute man" service. That's what you get when you specify Gas Atmospheres Packaged Gas Generation Systems.

You get full capacity and the dryness and purity you specified in quality-built packaged units that are set on a common base and completely factory tested prior to shipment. And, you can rely on the best factory trained service team in the business whenever your operation calls for it.

It's this kind of customer service that has made Gas Atmospheres Packaged Generators the most popular units working today. Gas Atmospheres makes a complete line of Packaged Generators for inert, CO_2, nitrogen, hydrogen, reducing and annealing gases. Literature available. Write *Gas Atmospheres, Inc., 20011 Lake Road, Cleveland, O.*

ONE FOR GOOD MEASURE!

You're always sure to be on the right track when the job is done by

rustrak® MAC*
miniaturized — automatic
CHART RECORDER

DIMENSIONS: 3⅝" w x 5⅝" h x 4⅛" d

$79.50
(1 MA DC)

Send today for complete specification sheet and prices.

* Miniaturized Automatic Chart Recorder

Jim Leeds wanted to check for electrical interruptions in equipment. A twenty-four hour vigilance on each unit was impractical — required increased manpower and expenditures. Upon extensive investigation, Jim found most automatic checking equipment cumbersome and expensive. What was the answer?

Jim found it in the amazing new palm-sized Rustrak® MAC,* the Miniature Automatic Chart Recorder. With an accuracy of 2%, it compared favorably with units costing 5 times its price. It recorded all interruptions with a continuous, distortion free line on a smudge-proof chart giving him an accurate, continuous record of any intermittence.

The new Rustrak® MAC,* Miniature Automatic Chart Recorder is solving hundreds of recording problems accurately and inexpensively.

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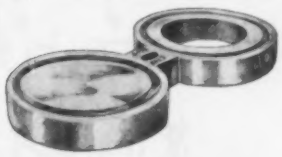
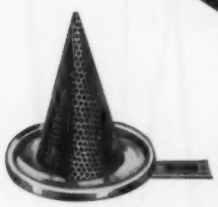
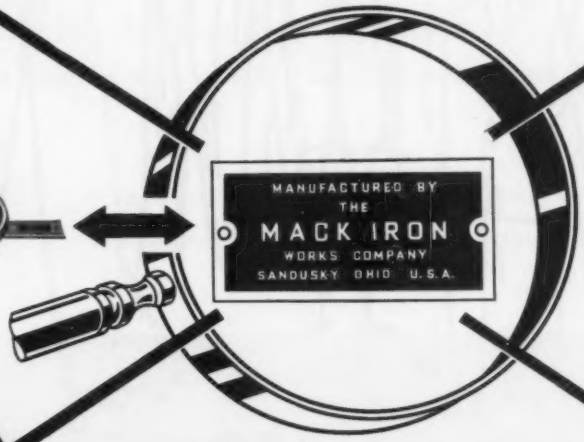
PHONE: CA 4-9131

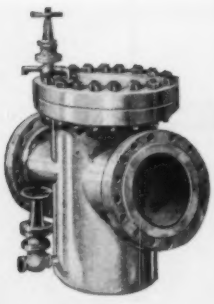
LITTLE TAG . . . BIG MEANING!



Not a mere name plate, this little metal tag on a piece of equipment is unreserved assurance of quality workmanship and dependability of service . . . *priceless characteristics not solely measured in dollars and cents.*







MAC-IRON CATALOG A-9

Although you'll find our full line Catalog A-9 in the current REFINERY CATALOG wouldn't you like more copies for distribution among your important engineering personnel?

Your request will bring all the copies you need.
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Stock and custom made items for many engineered applications which involve pumping of fluid materials and operational liquids.

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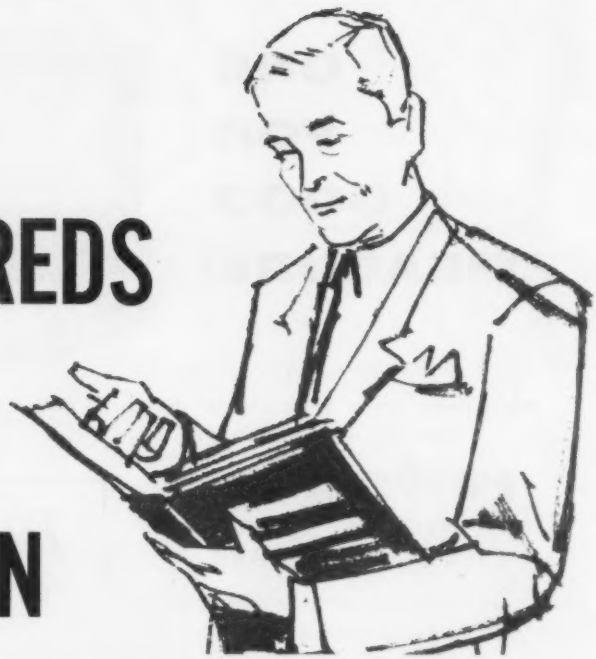

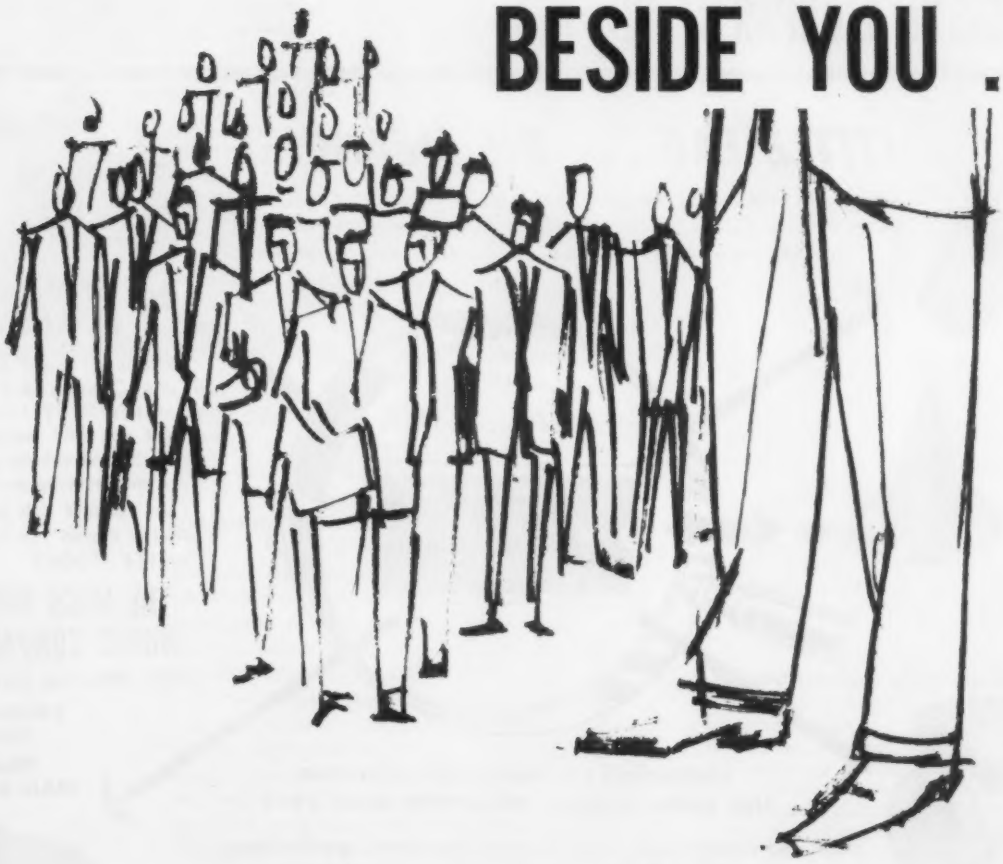

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World's Largest Specialized Publisher to the Oil Industries

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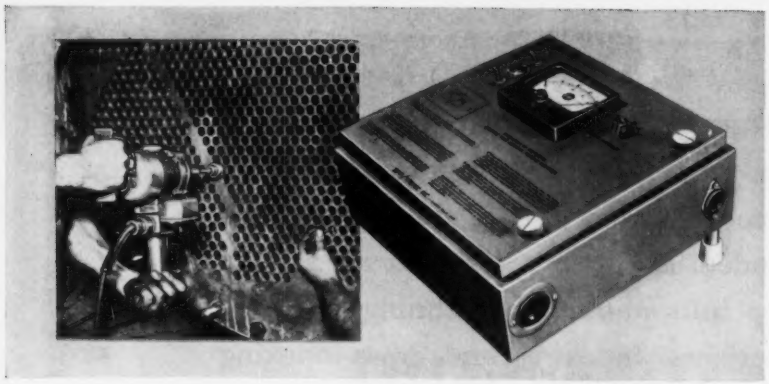

Your Motor + Wiedeke Torque Control = Increased Tube Rolling Production

Save the cost of a new motor! New Torque Control Instrument for rolling ¼" through 4½" tubes in boilers, condensers and similar heat transfer vessels—operates with any Universal Reversible Electric Tube Rolling Tapper or Motor. Adjustable time cycle matches operator's dexterity.

WRITE TODAY FOR DETAILS AND BULLETIN AC-7A

The Gustav WIEDEKE Company

DAYTON 1, OHIO

A UNIQUE CHECK VALVE THAT'S UNSURPASSED IN WATER, AIR, OIL OR GAS SERVICE

SILENT • SEATLESS • LOW PRESSURE DROP

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OUTPERFORMS • OUTWEARS OTHER VALVES • COSTS LESS TO MAINTAIN

In field service in a wide range of water, gas, air and oil applications, Technocheck's performance and reliability are unsurpassed. Its exclusive design eliminates valve seats. Tight sealing, low pressure drop and long life with low upkeep are some of its important characteristics.

SCHEDULE OF STANDARD VALVE SIZES

GENERAL DESCRIPTION	PSI	SIZES
Cast Iron, Flanged	125	4", 6", 8"
Steel, Male Threaded Ends	150	1½", 2", 2½", 3"
Steel, Flanged	150	3", 4", 6", 8"
PVC, Male Threaded Ends	125	1½", 2", 3"
PVC, Flanged	125	2", 3"
PVC, Flanged	50	4", 6", 8"

We invite inquiries on other sizes and in special materials.

Techno Corporation Dept. PR
16 West 5th Street, Erie, Pa.

Equipment . . .

the springless diaphragm, cylinder, and spring and diaphragm types for either on-off or throttling control applications. Conoflow Corp.

Circle E21 green card, last page

Booklet Tells "How To Communicate In Business"

A new 12-page booklet titled, "Fluid, Fluent Communications" has been released. The booklet emphasizes the importance of communications in today's business world and points out how an individual's success depends to a large extent on his ability to communicate effectively with his employers, employes and colleagues. The booklet outlines the pitfalls and dangers of improper communications and suggests many short-cuts an individual may use to improve his ability to communicate fluidly and fluently. The new booklet is the first of a series which is being published and is designed to help engineers develop and improve their personal and professional talents. Western Supply Co.

Circle E22 green card, last page

Process Control Technique Described In Catalog

Instruments for laboratory analysis, process control and research are described in a new 16-page general catalog just published.

Described are techniques and instruments for leak detection, mass spectrometry, chromatography, moisture monitoring, and other types of analysis and control. Consolidated Electrodynamics Corp.

Circle E23 green card, last page

Hydrogen Rich Gas Burner

Bulletin 57 on the HYDROCOOL Retention Nozzle, for inspirating gas burners, has just ben published. This improved gas burner nozzle provides safe operation with hydrogen or hydrogen-rich gases in various furnaces; also assures efficient burning of any other gas including the natural or by-product types.

These nozzles produce a shorter, hotter, stable flame with a high turn-down ratio, and with extremely low excess air in the nozzle. This nozzle obsoletes other makes where the previously used high-density gas has been replaced by low-density hydrogen. National Airoil Burner Co., Inc.

Circle E24 green card, last page

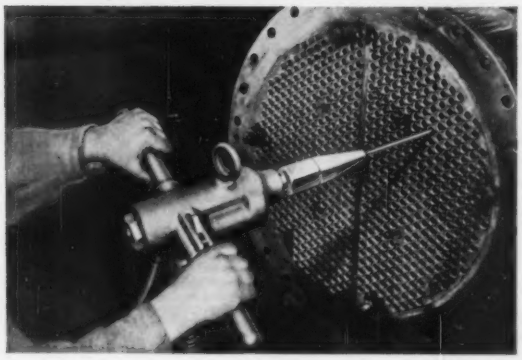
Liquid Desiccant Bulletin

A technical bulletin on HI-DRY liquid desiccant has just been published. This is a special grade of tetraethylene glycol for use in the removal of water from natural gas, which provides additional dew point depression and superior thermal stability properties. It can be used in conventional glycol absorbtion dehydration plants. Jefferson Chemical Co.

Circle E25 green card, last page

KNOCK OUT SCALE
WITH
SUPER-POWERED
WILSON TUBE CLEANERS

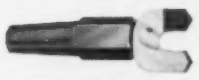
Are your heat exchanger tubes completely fouled with scale buildup? Or, are you looking for that last vital inch of heat transfer efficiency? In either case, efficient, hard-working Wilson Tube Cleaners are the answer.



For heavy duty service, for example, use Wilson air driven Model TP 301 shown above. This super-powerful, 15 lb, light weight, scavenger-type tube cleaner drills and simultaneously flushes out deposits. It is suitable for vertical or horizontal use in straight tubes 3/8" ID to 2 7/8" ID and up to 40' long. Cleans rapidly and thoroughly, operating at high speed at 90 psi. Can run on pressure as low as 50 psi. Other Wilson Cleaners are available for every tube size.

WILSON SUPER-DUTY CARBIDE BITS

TYPE M BIT
An inserted two-lip Helix type for general use. 1 1/32" to 1 19/32" bit OD.



TYPE K BIT
A two-lip Helix type with adaptor for general use. 1 1/4" to 2 3/4" bit OD.

TUBE EXPANDERS— Wilson Models 41 and 44 Self-Feeding Tube Expanders are modern tube expanders for the *precision rolling* of condenser and heat exchanger tubes into heavy tube sheets. Ball Bearing Collar Type 1/2" OD to 2 1/2" OD • **Write for your free copy of Wilson Catalog 77-88. It's a mine of information on tube cleaning and tube expanding problems.**

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BETTER TOOLS FOR BETTER WORK

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A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol

MAGNETROL
The World's Most Dependable
LIQUID LEVEL CONTROL

Because of the utter simplicity of Magnetrol's magnetic operating principle, standard models can be easily adapted to meet any special requirements for pressure, temperature or corrosive liquids . . . and usually at little extra cost. This Magnetrol versatility has solved all kinds of tough level control problems . . . and given our engineers wide application experience that can be invaluable to you.

Magnetrol is so simple that failure is all but impossible! Using only permanent, unfailing magnetic force for its operation, there's nothing to wear out . . . no diaphragms or bellows to stiffen and rupture . . . no electrodes to short or corrode . . . no packing to bind or leak. Magnetrol is practically maintenance-free! Magnetrol units are available for controlling level changes from .0025-in. to 150-ft. . . . with multi-stage switching when desired. Send coupon for full details.

MAGNETROL, Inc.

Send Coupon For Full Details

MAGNETROL, Inc., 2112 **S. Marshall Blvd., Chicago 23, Illinois**

Please send me catalog data and full information on Magnetrol Liquid Level Controls. 6

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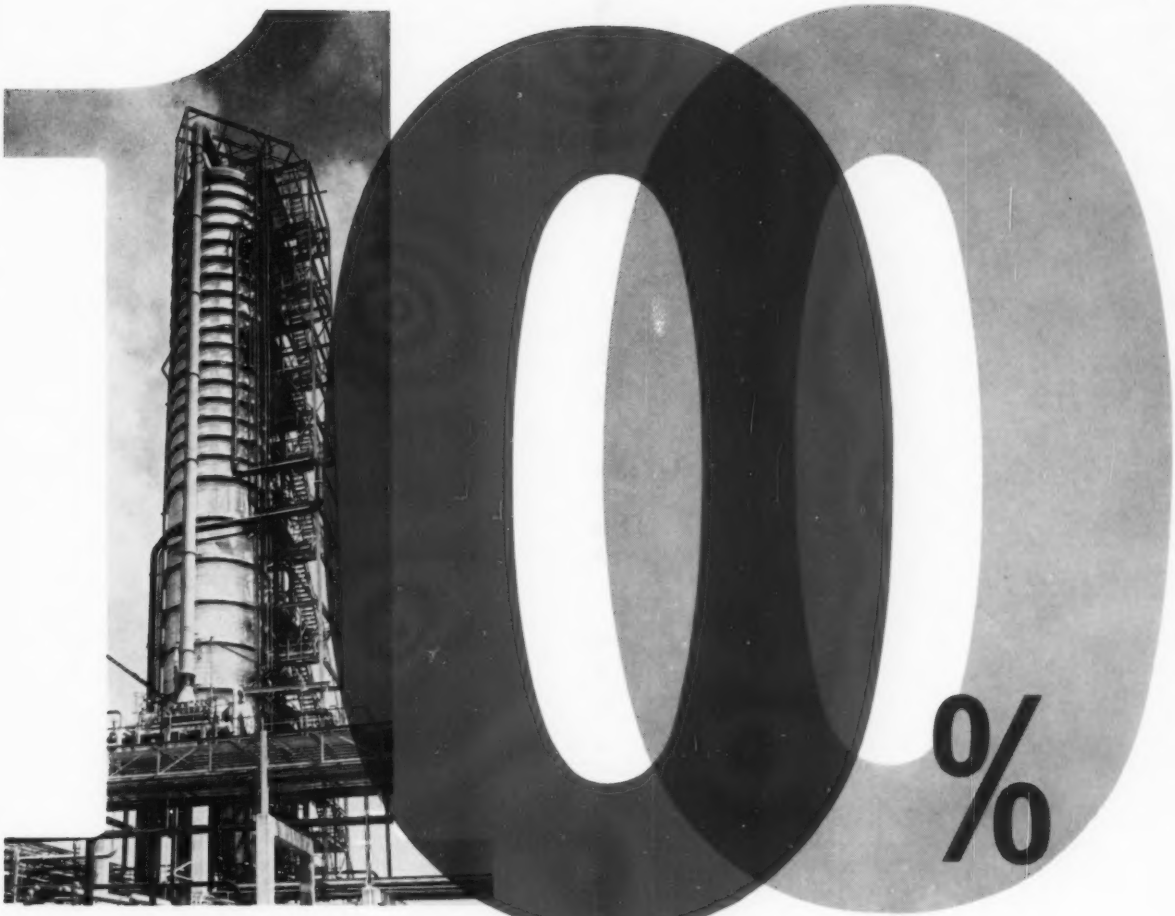

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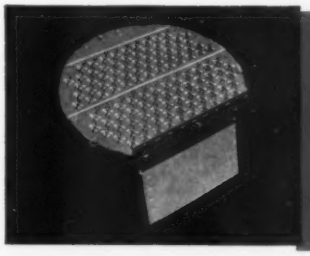

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